2004

A study of handling drops that occur when small packages move through small parcel delivery systems

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A Study of Handling Drops That Occur When Small Packages Move Through Small Parcel Delivery Systems

by

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A Thesis

Submitted to the

Department of Packaging Science

College of Applied Science and Technology

In partial fulfillment of the requirements for the degree of

Master of Science

Rochester Institute of Technology

2004

Department of Packaging Science
College of Applied Science and Technology
Rochester Institute of Technology
Rochester, New York

CERTIFICATE OF APPROVAL

M.S. DEGREE THESIS

The M.S. degree thesis of Robert J. Meisner
has been examined and approved
by the thesis committee as satisfactory
for the requirements for the
Master of Science Degree

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ACKNOWLEDGMENTS

I would like to thank the members of my thesis committee, Professor Deanna Jacobs, Mr. Thomas Kausch, and Mr. Dennis Young. Special thanks to Professor Jacobs for finding additional funding that made it possible to afford the tuition. Thanks to Thomas Kausch for actively supporting the study by supplying the data recording devices and spending time on his vacation editing the draft. Thanks to Dennis Young for his unwaivering support and the countless hours spent training the author how to use the data recording devices and answering lots and lots of questions.

I would also like to thank the following people for their financial support of the study: Mr. Walter T. Meisner from Syngenta Crop Protection for covering some UPS shipping costs and allocating the time and resources necessary to receive and return the test packages; Mr. Edward Church from the International Safe Transit Association (ISTA) for covering some of the FedEx shipping costs; Mr. Chad Thompson from United Parcel Service Professional Services Group for paying a portion of the UPS shipping costs and for his time discussing his distribution environment with me; Mr. Mike Baicor from FedEx Ground for covering part of the FedEx Ground shipping costs and answering many questions about how the shipments were actually handled.

In addition to those people who provided financial support I would like to thank all the program instructors, RIT staff and classmates for making this program a wonderful experience. Special mention and thanks to Mr. Steve Pierce for his guidance and expertise during the evaluation process of the data.

Although they were not directly involved in the study or the degree program, I would like to thank my parents and my wonderful wife. None of this would have been possible with out their support.

A Study of Handling Drops That Occur When Small Packages
Move Through Small Parcel Delivery Systems

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Abstract

A study was conducted of the drops that small packages encounter during handling operations in the small parcel ground delivery system of United Parcel Service (UPS) and Federal Express (FedEx), two of the largest small parcel carriers in the USA. The purpose was to determine if the drop heights listed in the International Safe Transit Associations (ISTA) standardized 3C and 3D testing procedure for small parcels replicate or are representative of the real environment. This is important to those who use ISTA tests to validate their package designs. The results of the study showed that relying on ISTA tests may result in over packing or under packing. Over packing is costly for the packager and results in unnecessary packaging material in the waste stream. Under packing may result in product damage which is also costly for the packager in terms of actual material costs and other expenses related to damage, such as the filing of damage claims with the carrier, lost business, reshipment of a replacement and customer dissatisfaction to name a few. If the environment is worse than the ISTA test procedure for small parcels, then the results could help the users modify the test procedure using some of the data collected in this study to come up with new drop heights for pre-shipment testing. If the environment is less severe than the current ISTA 3C and 3D test procedures, the data from this study could be used to develop a more representative drop test.

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Introduction

The focus of this thesis are drops that a small package, defined as less than 3 pounds, encounters during handling operations in the small parcel ground delivery system of United Parcel Service (UPS) and Federal Express (FedEx), two of the largest small parcel carriers in the USA. The purpose is to determine if the drop heights listed in the shock portions of the International Safe Transit Association's (ISTA) standardized 3C and 3D testing procedures replicate or are representative of the real environment. "Test procedure 3C covers testing of individual packaged-products weighing 150 pounds (68kg) or less when prepared for shipment via a parcel delivery service" (ISTA resource book 2004, pg 332) "Test Procedure 3D covers testing of small individual packaged-products that when shipped via a parcel delivery service maybe bagged by the carrier" (ISTA resource book 2004, pg 348). ISTA is a not for profit industry group dedicated to helping design packages that provide the right amount of product protection. One of the ways they do this is by developing and publishing pre-shipment testing procedures based on data they have acquired over many years in various modes of transportation. The procedures are used by packaging professionals to validate the package designs and to determine the probability of the packaged product arriving at its intended destination damage free. Most of their testing procedures suggest that a package will experience a particular number of drops during distribution and the heights of those drops will vary based on the weight of the package being tested. Test procedures 3C and 3D were developed specifically to test small packaged products in parcel delivery systems. These procedures call for multiple drops from different heights ranging from 15 to 30 inches. This is important to those packaging professionals who use ISTA tests to validate their package designs. Results of the current study may suggest that relying on ISTA tests results in over packing or under packing. Over packing is costly for the packer and results in unnecessary packaging material in the waste stream. Under packing results in product damage which is also costly for the packager in terms of actual material costs and other expenses related to damage, such as the filing of damage claims with the carrier, lost business, the reshipment of a replacement and customer dissatisfaction, to name a few. If the environment is either better or worse than the ISTA test procedures for small parcels, the data collected in this study could be used to develop new drop heights for pre-shipment testing that are more representative of the actual environment.

Literature Review

Many studies have been done to determine how often and from what height packages are dropped during distribution. Several of these studies were reviewed to determine if the proposed testing had already been done. Most of the tests compiled drop heights and looked at various modes of transportation including United Parcel Service air and ground services. The smallest package used to gather information was 10" x 10" x 10" weighing in at 10 pounds used by Pierce.

Steve Pierce (2002) studied Less-Than-Truckload (LTL) shipments both domestically and internationally with a variety of package sizes and weights. Domestically he used two packages. One was 10 x 10 x 10 inches and weighed 10 pounds, the smallest package used in any of the studies. The second was 11 x 11 x 13 inches and weighed 35 pounds. He combined all the data and found that the mean drop height was 13.8 inches, the median (50% or less) was 11 inches, and the mode was 8 inches. The mean drops per trip were 7 drops, the median was 6 drops, and the mode was 8 drops.

Donald J Appleton (1997) studied drop heights that occurred both domestically and internationally using three different size and weight packages. The domestic small parcel portion of his study started in Rochester, NY, 7and terminated at various locations throughout the USA.

His study found that the weight of the packages did not greatly affect the drop heights recorded, so the drop height data from the three different packages was combined and the following results were tabulated. The mean drop height was 9.3 inches, the median was 8 inches, and the mode was 5 inches. The mean drops per trip were 2.8, the median was 2, and the mode was 1.

Timothy Grant Weigel (1996) used drop height recorders to determine if there were differences in the way wooden and corrugated packages were handled with and without fragile labels. He used the overnight services of Federal Express and the United States Postal Service. He not only looked at drops but also impacts. He found that corrugated packages averaged almost twice as many shock events than the plywood containers, and the labels had very little effect on the number of events recorded for each package. For the purpose of comparing it to this study, the only useful data was that which showed 95% of the drops the corrugated container received were below 23.6 inches. Even with that, the service level and physical package characteristics do not make this a good comparison to this study.

S.P. Singh and T. Voss (1992) studied the UPS ground shipping environment to determine if the size and weight affected drop heights. The package sizes varied from a 12 x 12 x 12 inch cube weighing 20 pounds up to a 26 x 20 x 19 inch container weighing 45 pounds. They concluded that the size of the package had little effect on drop heights, but the weight did play a role in drop heights on the smaller, lighter packages. The idea that smaller lighter packages will encounter higher drop heights can be confirmed with this study.

Ostrem and Godshall (1979) reviewed many studies and compiled a report to summarize the findings of all the studies reviewed. They concluded that packages would receive many shocks during distribution, but mostly from lower heights. They also concluded that heavier loads would receive fewer drops from lower heights than smaller, lighter packages. This fact is reflected in the

ISTA drop procedures, which requires the drop heights to decrease as the package weight increases.

After reviewing the above literature and other general packaging studies it was determined there was conflicting information regarding drop heights as they related to weights, and none of the studies looked at the very small, lightweight packages proposed by this study. Furthermore, many of the studies used different carriers and service levels, such as overnight shipments, and different modes, such as aircraft, and, because of these variables, there is no way to do a direct comparison. None of them compared their results with ISTA testing procedures.

Test Plan

Because of their small parcel market domination in the USA, United Parcel Service (UPS) and Federal Express (FedEx) were used to ship the packages. Identical packages contained a Lansmont SAVER™, hereafter simply referred to as SAVER™. The SAVER™ is an electronic instrument capable of measuring and recording change in direction and change in velocities. The collected data was then downloaded and interpreted by the SAVER™ software that converted the data using mathematical calculation to determine the height from which the package was dropped. The SAVER™ is also sophisticated enough to determine what part of the package was impacted when dropped. The packages were small-corrugated boxes measuring 7 inches long, 6 inches wide, and 5 inches deep, with a final loaded shipping weight of 2.8 pounds (see Figure 1). The corrugated box was a Regular

Figure 1. Saver package

Slotted Container (RSC) made of single wall C-flute corrugated fiberboard with a Mullen burst test rating of 200 pounds and an inside flap secured with tape. The inside of the package was lined with 1.7 pound density laminated polyethylene foam with an overall thickness of one inch. The foam was cut and fit to allow for 1 inch of protection around all surfaces of the SAVER™. The cushioning was used to protect the SAVER™ from receiving excessive shock levels during the testing. A new RSC was used every time the package was sent from Dayton to ensure adequate containment and protection during each shipment. The cushioning material was replaced after three round trips between Dayton, Ohio (DAY), and Greensboro, North Carolina (GSO), because by the end of the third trip, the SAVER™ could be felt shifting inside of the sealed package.

The SAVER™ devices were programmed to record drop heights as they occurred (event recording), including a time stamp when each event occurred. The time stamps of the events were used in conjunction with the tracking information provided by the carrier to determine if the package was in their possession and in transit at the time an event was recorded. All non-handling events were later eliminated from the summary of events. The programmed SAVER™ was placed into the foam lined RSCs and sealed using 3 inch wide clear box sealing tape, 3M brand, number 375. The shipping label was affixed to the top of the box, and the packages were delivered to their prospective carriers' drop locations, which remained the same throughout the testing. All packages were addressed to the same person at the same location in GSO. Once the package arrived in GSO the packages were dropped from 18 inches using a Lansmont drop tester. The date, height, and time of the drops were recorded on the outside of the package. The purpose of the drop conducted by the receiver in GSO was a calibration drop to determine if the recorder was functioning correctly. If the drop height calculated by the SAVER™ matched the actual drop height, then the data collected throughout the test was considered valid. The calibration drop event was eliminated from the final data. Following the calibration drop the package was relabeled with a new shipment number and sent back to DAY using the same carrier and ground service used to get the shipments to GSO. Upon receipt in DAY the data collected was downloaded and saved for later evaluation. The SAVER™ was then reset and packaged for another round trip. When resetting the device the same parameters for data acquisition were used, and the previously collected data was deleted. The goal was to have as many shipments as possible with an equal number of shipments with each carrier in the allotted 4-month time frame used for the collection of data. The results of the drop heights recorded were then compared to those required by the current ISTA 3C and 3D test procedures.

Study Preparation

Any scientific study requires many things to be thought out, planned, and learned before useful data can be compiled and evaluated. Preliminary work for this study involved learning how the SAVER™ functioned, how to program it, and how to interpret the data. A test plan also had to be established to define what information was going to be gathered using what routes and what carriers. Package size and shape were also defined, and the sample packages fabricated.

The first step was reviewing the manufacturer's software and instruction booklet that was provided with the SAVER™. The learning process also involved special training sessions with an expert. This training included actually programming the devices, loading the test plans, conducting calibration drops, downloading the data, and data analysis.

The actual programming involved setting up the parameters for what type of events would be recorded and at what levels of force the SAVER™ would be triggered to record the events. The trigger levels were set based on the expert's knowledge of the SAVER™ and the distribution environments I would be testing. The number of timed events that would be recorded was determined by the amount of memory available on the SAVER™ unit with the smallest memory and duplicated on the second SAVER™. The recording parameters were then downloaded into the SAVER™ using a desktop computer serial port cable and the manufacturer's supplied software. Controlled test drops were then conducted in a laboratory using a Lansmont drop tester (see Figure 2). The height of the drops, the time the drops occurred, and the orientation that the package was dropped from were all noted during the testing so that they could be compared with the events recorded by the SAVER™. This process was two fold; first it served as a calibration to determine if the device interpreted the event correctly, and secondly it helped the author recognize what the SAVER™ output data looked like for specific events. After approximately one dozen drops in the laboratory, the SAVER™ was removed from the package and the data downloaded as a Di1 file for later analysis. Di1 is the format used by the SAVER™ to save the raw data files of each event recorded. When the analysis was conducted, the Di1 file was opened and all the events recorded were analyzed individually.

Figure 2. Lansmont drop

The analysis process involved several steps. The first step was to eliminate non-carrier events using the SAVER™ time stamp and the carriers' tracking information. The second step was to scroll through each event until a shock of 10g or greater was noted. All the events at or above 10g were selected for evaluation while all events below a shock level of 10g were discarded.

The software tries to calculate the drop height automatically and places red boundary lines where it calculated the shock began and ended. Often these marks do not accurately mark the beginning and end, so manual boundaries can be established by the user. The software will then calculate the drop height based on the manual boundaries. Once an event was selected for analysis, the right hand boundary was manually located in the middle of the upward portion of the impact section of the shock pulse. The left hand boundary was then placed at the beginning of the free fall section of the shock pulse (see Figure 3). The software then calculated the equivalent drop height based on the data between the boundaries, and that event was added to the summary of drop events.

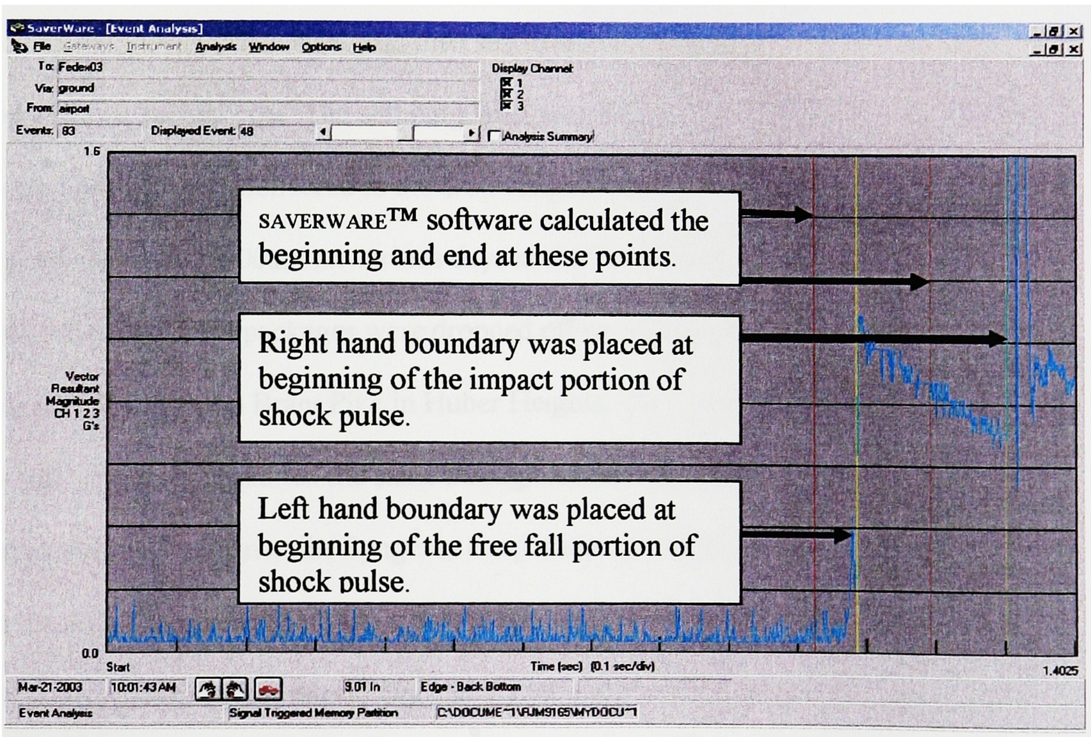

Figure 3. Event analysis screen

Implementing the Plan

The SAVER™ was connected to a desktop computer and turned on. The SAVERWARE™ software was used to talk with the SAVER™ device and to download the preprogrammed test protocol including a delayed start 15 minutes before the anticipated time the unit would be delivered to the carrier. Once the SAVER™ was loaded and programmed with the start time, it was turned off and disconnected from the computer. A shipping label was then generated by going on-line to the carrier's website. The tracking number on the label was noted in a shipping log for later use. The RSC was set up, and the cushioning was inserted. The SAVER™ was turned on and placed inside the package, and the front, top, left and right orientation of the device was noted on the outside of the package. The RSC was then sealed using the six strip method and 3 inch wide 3M Brand 275 box sealing tape. The shipping label was affixed across the top of the package, and the 2.8 pound package was delivered to the drop off points the following day. FedEx shipments were dropped off around 8:00am on various days at the FedEx facility located at the Dayton International Airport. UPS packages were dropped off on various days just prior to the 5:00 pm pick-up at the UPS Store on Brant Pike in Huber Heights, Ohio. The FedEx and UPS drop off locations that were used remained the same throughout the entire study. All packages were addressed to the same person at the Syngenta Corporation packaging laboratory in GSO. Upon arrival at Syngenta, the packages were processed through the Syngenta internal mail service and delivered to the packaging laboratory. Once in the laboratory, the packages were inspected for damage and the calibration drop was conducted and recorded. The packages were then relabeled and returned to the shipping department for pickup by the carriers and returned to DAY using a new shipment number. Once the package was delivered to the DAY destination the SAVER™ was removed and the data was downloaded and saved to floppy disc and onto the desktop computer's hard drive for later evaluation. This process was repeated 7 times with FedEx and 10 times with UPS. The reason for the different number was primarily due to pickup schedules at Syngenta and differences in transit times. Once the SAVER™ was returned, the shipping tracking numbers used to and from GSO were used to download the tracking information from the carriers' websites. That printed tracking data was catalogued and used later during the evaluation process.

Data Analysis

A process of consistently selecting and analyzing the recorded events was needed for the purpose of the study. A formal process was needed to ensure all data was treated the same way every time, regardless of carrier, and to ensure the data was statistically significant. The preliminary sorting process was actually very simple and was based on suggestions from other packaging professionals who were very well versed in the evaluation of SAVER™ data.

The first step was to go through each data file and eliminate events that did not occur during the carrier's handling operations. Any event recorded prior to the package being tended to the carrier and any events that occurred when the package was not in the carrier's possession were eliminated. This was possible using the tracking information provided by the carrier and personal documentation that included the time the packages were tended to the carrier and the time and date the calibration drops were conducted.

The second step was to eliminate any events that did not occur during handling or sorting operations. Non-handling events were those that occurred when the package was in transit. These non-handling events were identified using the tracking information provided by the carrier. This information shows the time a package was loaded or unloaded at each point during distribution. The time between loading and unloading was "in transit" time, and therefore any events that occurred in transit were not handling drops. However, due to the fact that the packages were handled briefly before and after the scan prior to the vehicles being loaded or unloaded, events that were within 15 minutes of the loading or unloading scan times were not eliminated.

The third step used to eliminate remaining events as non-handling drops was to use the scale on the event viewer screen within the SAVERWARE™ software. The scale on the event viewer graph automatically adjusts based on the shock pulse it is trying to display (see Figure 4).

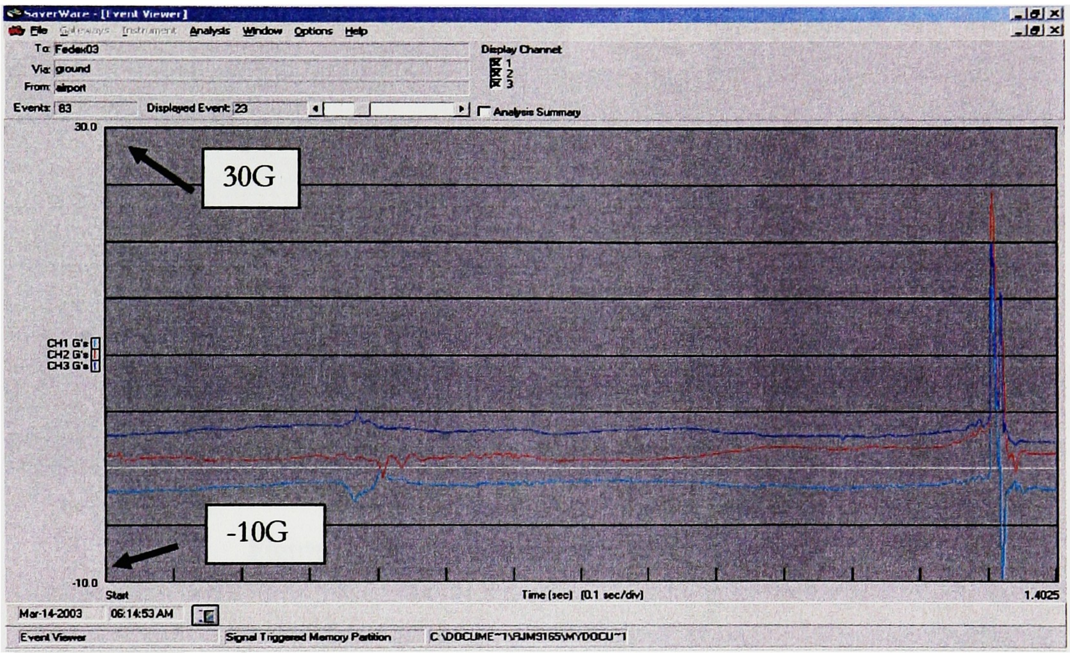

Figure 4. "G" scale in event analysis viewer

If the + or – scale was equal to or greater than 30g's, then that event was kept for further analysis. If the + or – scale was equal to12g's but greater than 6g's, the event was ignored unless the shock pulse was obviously the result of a drop which is characterized by the shock pulse in Figure 5. If the + or – scale was equal to or less than 6g's, the event was completely ignored. These levels were established based on the knowledge and experience of industry experts familiar with evaluating

SAVER data. The remaining events were reviewed individually to determine if they were legitimate drops and not impacts or some other event that was large enough to trigger the SAVER. Once the analysis was completed on each of the data files the remaining events were used to perform statistical analysis and create graphical representations of the findings.

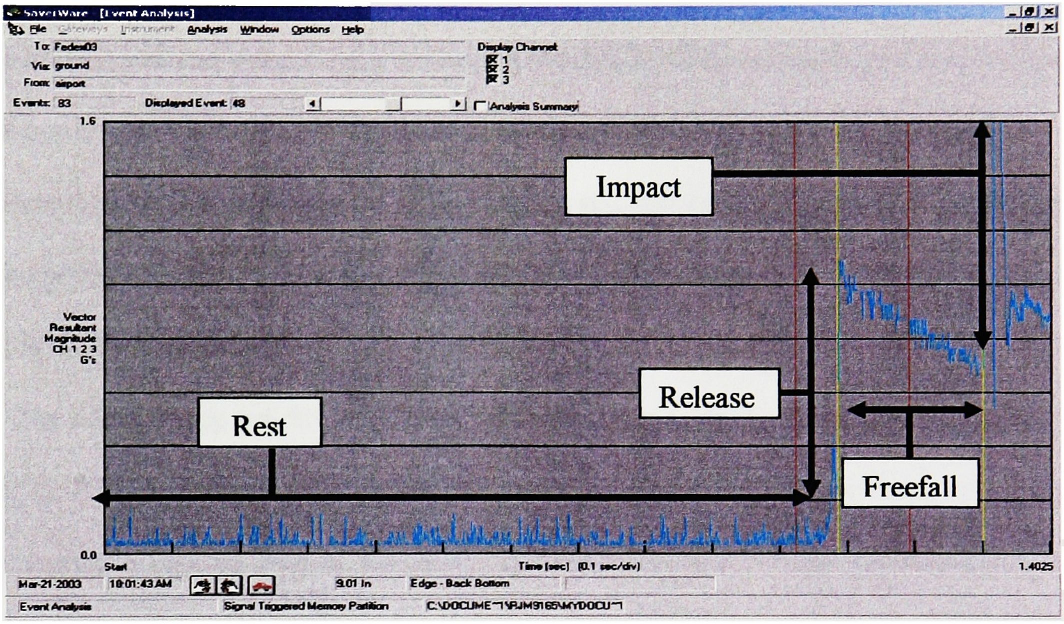

Figure 5. Shock pulse in event analysis viewer

Results and Discussion

With a few exceptions the data collection portion of the study went very well. However, because of battery problems the data for FedEx Ground 1 to and from GSO and the return shipments of UPS 7 and UPS 10 did not fully record. The data from those trips were not included in the summary results. The most time consuming and difficult portion of the study was the event analysis. Even with the procedure outlined in the data analysis section in place, there were instances when there would be a dramatic event recorded, but because of the complexity of the waveform, it was unclear what actually happened, and some personal judgment had to be used to determine if it was a drop or should be included in the final data.

Originally procedure 3D was selected to compare against the results. Procedure 3D is for small packaged products weighing less than 150 pounds bagged in parcel delivery system shipments (see Appendix A). 3D seemed like the test that would apply to the sample packages because of their size and weight. After collecting the data and discussing the preliminary results with the carrier representatives, it was determined that FedEx Ground did not use bags to consolidate their smaller packages for further sorting and distribution like UPS, so procedure 3C, packaged product for parcel delivery system shipment 150 lb or less (see Appendix B), also had to be used in the final evaluation.

The average drop height varied little between carriers, but the average drop heights required by ISTA Test Procedures 3C and 3D were significantly higher (see Figure 6). UPS was the lowest with an average drop height of 10.3 inches. FedEx Ground was only slightly higher with an average drop of 12 inches. ISTA Procedure 3C was 17 inches while Procedure 3D was 30 inches.

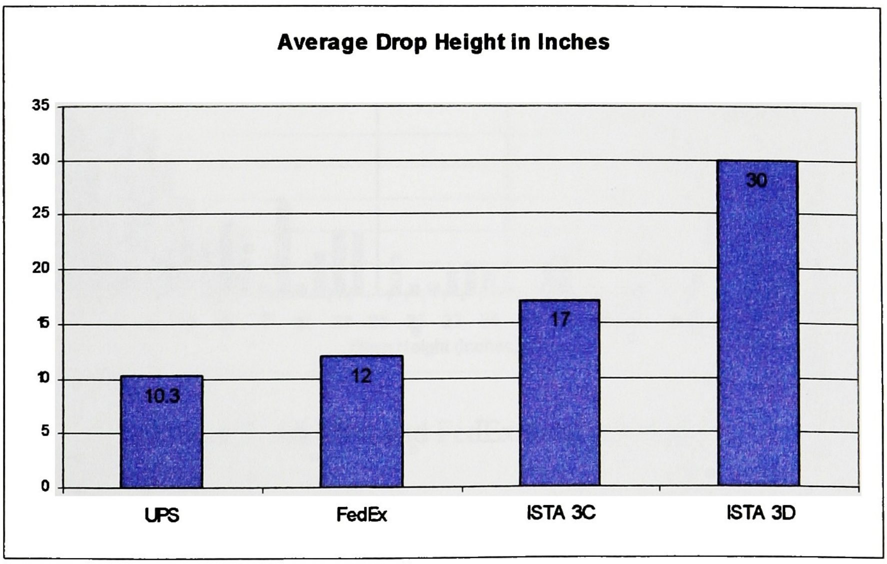

Figure 6. Average drop heights.

Based on these averages, it would appear that the ISTA tests are more severe than the real environment. However, ISTA procedures were developed to encompass more than the average event and had to be representative of nationwide distribution using a variety of modes and service levels. According to one ISTA officer the tests were put together to represent about 95% of the drop events one could expect to see regardless of domestic shipping locations or modes selected. Given that, at the 95 percentage range for each carrier the drop heights encountered are very close to those required by ISTA (see Figure 7). Although ISTA 3D does drop the parcel bag from 30 inches, the resultant force received by the packages inside would often be somewhat less than a single package being dropped on a hard surface, as is required in ISTA 3C, because of the cushioning effect of the surrounding packages in the same parcel bag.

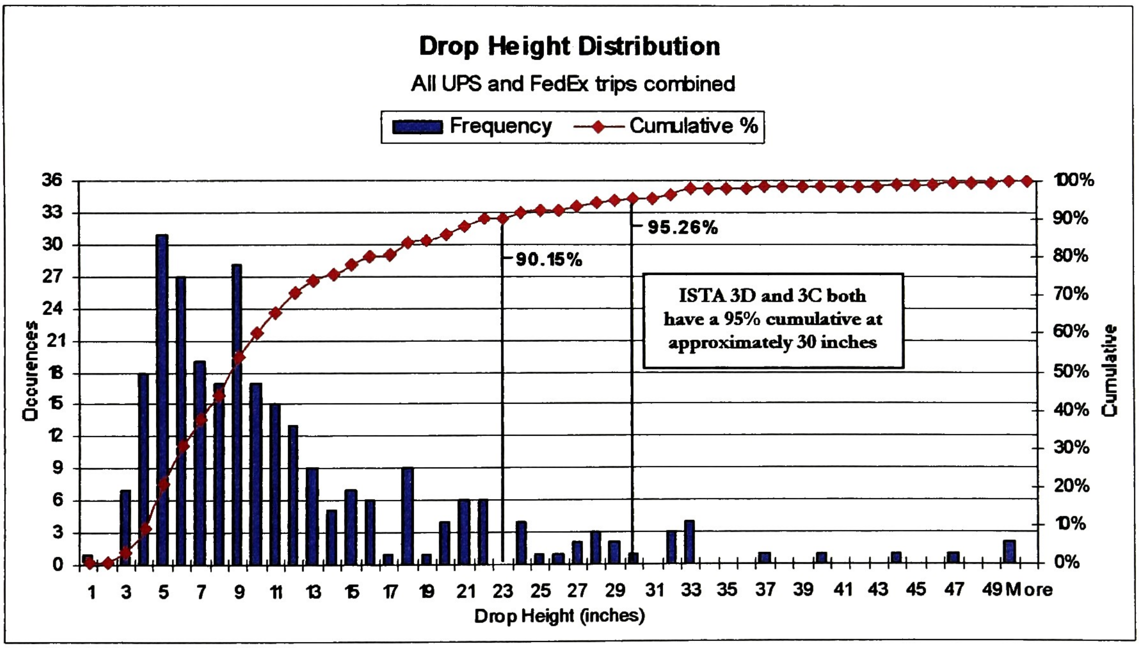

Figure 7. All UPS and FedEx drops combined

There were a large percentage of impacts and other events that triggered the SAVER™ each trip that were not handling drops, but rather some other impact event (see Figure 8). For example 89.32% of the events recorded in the UPS environment were not handling drops and 74.68% of the FedEx Ground events were not handling drops. Given that high number, one could consider the higher average drop heights of the two ISTA Procedures as a safety factor used in place of many additional drops. Therefore, using the ISTA test procedure at face value would prove very effective without worrying about over packing.

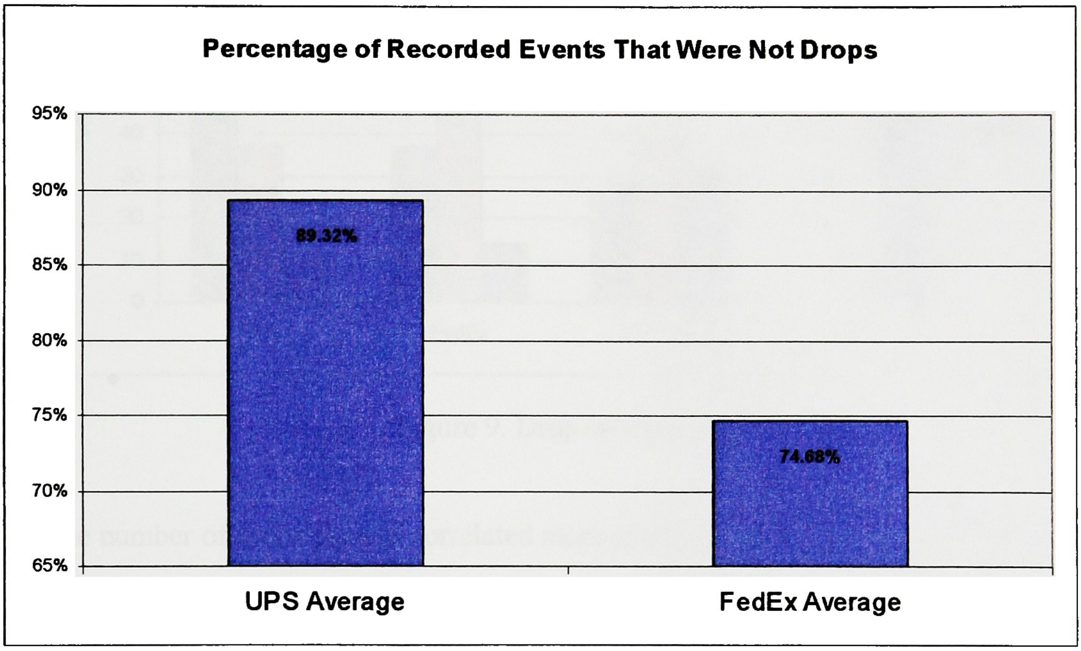

Figure 8. Non-drop events

The orientation of drops was also compared. The study showed 44% were edge drops, 40% were corner drops, and 16% were flat drops. The difference between carriers was extremely close, and Figure 9 compares the orientations of drops recorded with those required by ISTA procedures. The percentage recorded in this study were very close to what others have recorded in previous studies regardless of the mode of transportation or service level selected. Although the ISTA 3D procedure requires the parcel bag to be dropped in the flat orientation, the package inside can impact in virtually any orientation, and very rarely will they impact flat.

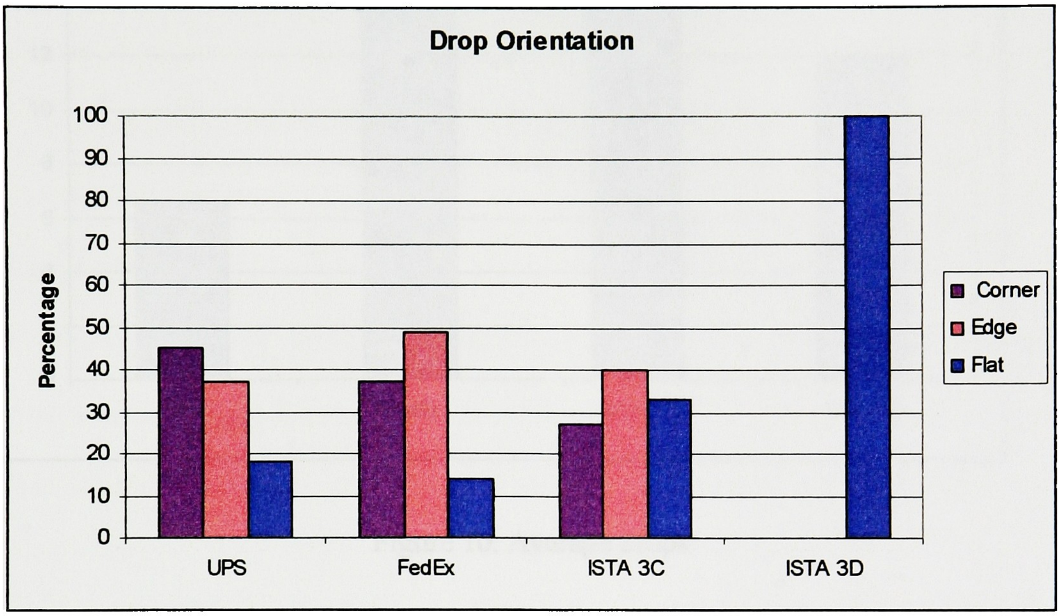

Figure 9. Drop orientations

The number of drops per trip correlated more closely to the collected data from one carrier than the other as seen in Figure 10. The average number of drops encountered with FedEx Ground was 14.18 per trip. ISTA 3C requires 15 drops, while 3D requires 12 drops. UPS only averaged 6.55 drops per trip. Part of this may be explained by examining the tracking information. FedEx Ground typically was moved through 5 points before final delivery, while UPS only moved through 3 points. The more frequently a shipment is sorted, the more it is handled, and the probability of drops and impacts is increased. Furthermore, FedEx Ground did not bag the package and therefore had to handle it individually many times between origin and final delivery. In both cases, the more a shipment is handled, the more likely it will be dropped.

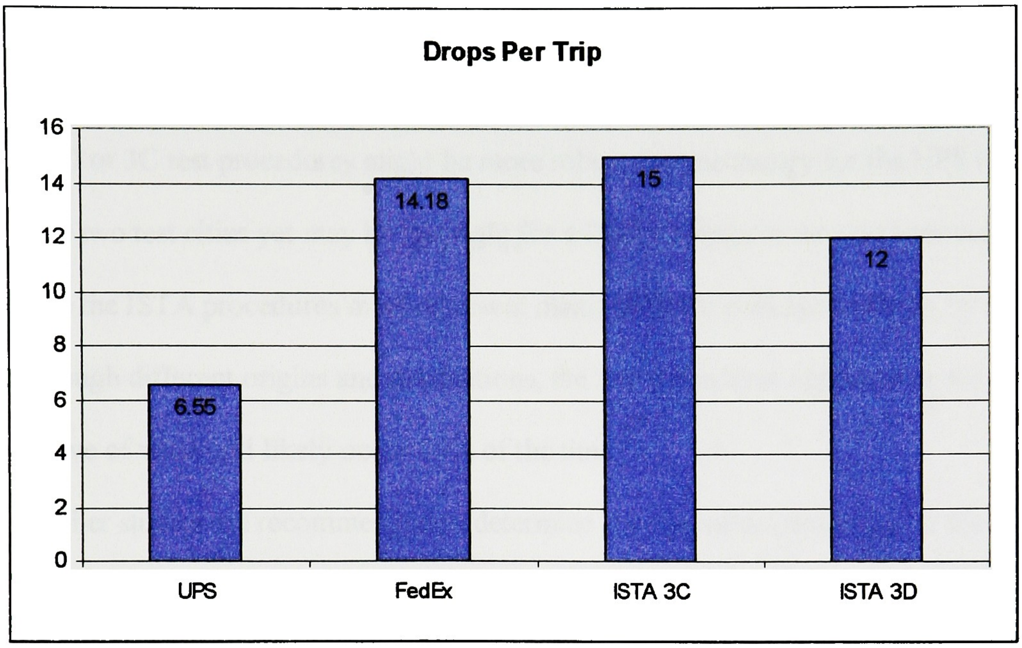

Figure 10. Average drops

Based on all the results it is clear that the carrier and, more specifically, the routing used and the numbers of times the carrier will handle a shipment before delivery have a dramatic effect on the number of drops and impacts a package receives. Based solely on the specific routing selected for this test, it would appear that the height of the drops called for in the ISTA 3D procedure are too high, although caution must be exercised when determining if that should be reduced. There were times when drop heights recorded exceeded the drop heights called for in the testing, and only the packers can determine if they are willing to take the risk of not including such heights when conducting performance tests on their packages. Based on the cumulative drop height for each carrier, one could expect to see 90% of UPS drops to occur from approximately 20 inches or less, while FedEx Ground had 90% of their drops occur from approximately 24 inches or less.

This research further confirms that there are a lot of variables to consider when defining the normal handling environment. Based just on this study it appears that a package designed to pass the ISTA 3D or 3C test procedures might be more robust than necessary for the UPS routing between the two test cities yet may be just right for a FedEx shipment moving between these same cities. Since the ISTA procedures must represent many different packages moving by various carriers through different origins and destinations, the test procedures appear to be very representative of what will likely occur 95% of the time.

Further studies are recommended to determine the equivalent drop heights that a package incurs when subjected to the ISTA 3D test. The test calls for multiple 30 inch drops but the packages inside most likely will not receive a shock with the equivalent drop height of 30 inches.

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Appendix A

ISTA Procedure 3D

Small Packaged-Products
Bagged in Parcel Delivery System Shipments

3D 2001

ISTA 3 Series
General Simulation
Performance
Test Procedure

ISTA, Your Alliance in Transport Packaging, is the world leader in Performance Tests for Packaged-Products.

ISTA 3 Series tests are advanced tests.

- They challenge the capability of the package and product to withstand transport hazards, **but**
- They use general simulation of actual transport hazards, **and**
- They do not necessarily comply with carrier packaging regulations.

When properly applied, ISTA procedures will provide tangible benefits of:

- Shortened packaged development time and confidence in product launch
- Protection of products and profits with reduced damage and product loss
- Economically balanced distribution costs
- Customer satisfaction and continued business.

There are three sections: Overview, Testing and Report

- **Overview** provides the general knowledge required before going into the testing laboratory **and**
- **Testing** presents the specific instructions to do the testing in the laboratory **and**
- **Report** indicates what data shall be recorded to submit a test report to ISTA.

Two systems of weights and measures are presented in ISTA test procedures. They are the English system (Inch-Pound) and the international system SI (Metric). Inch-Pound units are shown first with Metric units in brackets, except in some tables where they are shown separately.

- Either system may be used as the unit of measure (standard units), **but**
- The standard units chosen shall be used consistently throughout the procedure.
- Units are converted to two significant figures **and**
- Not exact equivalents.

VERY IMPORTANT:
The entire document shall be read and understood before proceeding with a test.

OVERVIEW OF PROCEDURE 3D

Preface

Test Procedure 3D is a general simulation test for small packaged-products that become unitized with other packaged-products in any type of transport bag by parcel delivery carriers.

- It can be used to evaluate the protective performance of packaged-products related to vibrations, shocks and other stresses normally encountered during handling and transportation.
- The test levels are based on general data and may not represent any specific distribution system.
- The package and product are considered together and not separately.
- Some conditions of transit, such as moisture, pressure or unusual handling, may not be covered.

Other ISTA Procedures may be appropriate for different conditions or to meet different objectives.

Specific suggestions:

- For packaged products larger in dimension than 12 x 12 x 3 inches (310 x 310 x 80 mm) and/or over 10 lbs. (4.5 kg) in weight use ISTA Test Procedure 3C and not 3D.
- Refer to *Guidelines for Selecting and Using ISTA Procedures and Projects* for additional information.

3D

OVERVIEW OF PROCEDURE 3D

Scope

Test Procedure 3D covers testing of small individual packaged-products that when shipped via a parcel delivery service maybe bagged by the carrier.

Product Damage Tolerance and Degradation Allowance

The shipper shall determine the following prior to testing:

- What constitutes damage to the product **and**
- what damage tolerance level is allowable, if any, **and**
- the correct methodology to determine product condition at the conclusion of the test **and**
- the acceptable package condition at the conclusion of the test.

For additional information on this determination process refer to *Guidelines for Selecting and Using ISTA Procedures and Projects.*

Samples

Samples should be the untested actual package and product, but if one or both are not available, the substitutes shall be as identical as possible to actual items.

Number of samples required:
One sample is required for the tests in this procedure.

Replicate Testing Recommended:
To permit an adequate determination of representative performance of the packaged-product, ISTA:

- Requires the procedure to be performed one time, **but**
- Recommends performing the procedure five or more times using new samples with each test.

NOTE:
Packages that have already been subjected to the rigors of transportation cannot be assumed to represent standard conditions. In order to insure testing in perfect condition, products and packages shipped to certified laboratories for testing must be:

- over-packaged for shipment to the laboratory **or**
- repackaged in new packaging at the laboratory.

Test Sequence

The tests shall be performed on each test sample in the sequence indicated in the following table:

Sequence #	Test Category	Test Type	Test Level	For ISTA Certification
1	Shock	Drop	30 inches (760 mm)	Required
2	Vibration	Random	Overall G_{rms} level of 0.52	Required
3	Shock	Drop	30 inches (760 mm)	Required

3D

EQUIPMENT REQUIRED FOR PROCEDURE 3D

Equipment Required Shock

Free Fall Drop Test:

- Free Fall Drop Test System complying with of the apparatus section of ASTM D 5276-98.

Equipment Required Vibration

Random Vibration Test:

- Random Vibration Test System complying with the apparatus section of ASTM D 4728-01.

Equipment Required Additional

- Two United States Postal Service #1 Mailbags or equivalent [approximately 39 x 27 inches (1.0 x 0.7 meters)] used throughout the testing sequence.
    - One bag is filled with 200 pounds (90 kilograms) of sand suitably packaged in smaller bags.
    - Sample Bag to be filled with the Test Specimen and dunnage made of wood, high density poly-ethylene or similar density materials in the following numbers and sizes:
    - 24-cylindical pieces approximately 6 inches (150 mm) in diameter and 3 inches (80 mm) high weighing approximately 0.5 pound (230 grams).
    - 8-Small rectangular blocks approximately 6 x 6 x 0.5 inches (150 x 150 x 13 mm) weighing approximately 1.5 pounds (680 grams).
    - 8-Large rectangular blocks approximately 11 x 5 x 1.5 inches (280 x 130 x 38 mm) weighing approximately 3.3 pounds (1.5 kilograms)

3D

BEFORE YOU BEGIN PROCEDURE 3D

Identification of Faces

Prior to beginning the tests identify the faces according to the procedure below.

With the empty mailbag lying flat:

- Mark the face that is up as 1.
- Turn the bag over and mark the opposite face with 2.
- The bag opening shall be considered the top.
- The end opposite the top shall be considered the bottom.

Before You Begin Shock Testing

Fill a #1 mailbag with a mixture of products that represent the product mix to be evaluated plus the dunnage:

The drop height shall be 30 inches (760 mm) as measured from the lowest part of the bag, if over hanging the drop platen.

Before You Begin Vibration Testing

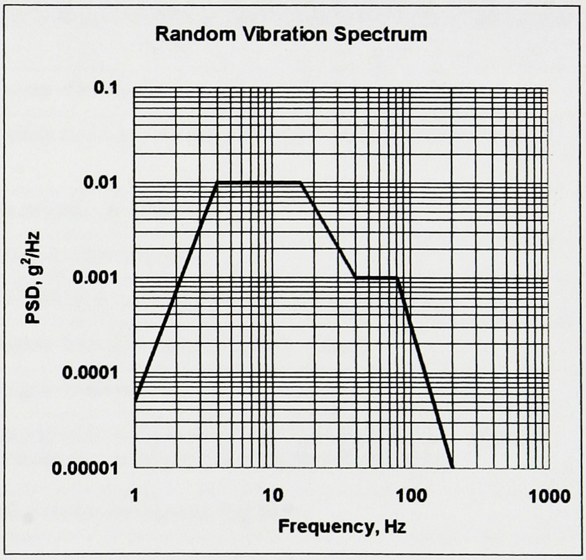
CAUTION:

A restraining device or devices shall be used with the vibration test system to:

- Prevent the test specimen from moving off the platform **and**
- Maintain test orientation of the packaged-product or stack, **but**
- The device or devices shall not restrict the vertical motion of the test specimen during the test.

The following breakpoints shall be programmed into the vibration controller to produce the acceleration versus frequency profile (spectrum) below with an overall G_{rms} level of 0.52

Frequency (Hz)	PSD Level, g^2/Hz
1.0	0.00005
4.0	0.01
16.0	0.01
40.0	0.001
80.0	0.001
200.0	0.00001



3D

TEST SEQUENCE FOR PROCEDURE 3D

The test blocks that follow contain tables that indicate the required steps for each test in the procedure.

First Shock Test Block

DROP	
Step	**Action**
1	Test the packaged-product according to the level in the Before You Begin Block. Follow the sequence in the table below.
2	Shock testing is now complete. Go to the Vibration Test Block.

Drop #	Packaged-Product Orientation
1	Bottom
2	Face 1
3	Face 2
4	Bottom
5	Face 1
6	Face 2

Vibration Test Block

RANDOM	
Step	**Action**
1	Place the specimen bag on the center of the vibration table with face 1 in the down orientation.
2	Start the vibration machine to produce the random vibration spectrum indicated in the Before You Begin Block.
3	Stop the vibration machine at the completion of 30 minutes.
4	Turn the bag over so that face 2 is in the down orientation.
5	Place another #1 mailbag filled with 200 pounds (90 kg) of sand on top of the test specimen.
6	Start the vibration machine to produce the random vibration spectrum in Step 2.
7	Stop the vibration testing at the end of 30 minutes.
8	Inspection of the packaged-product for visible damage is allowed, provided inspection does not alter, in any way, the current condition of the package or the condition or position of the product(s).
9	Vibration testing is now complete. Go to the Second Shock Test Block.

TEST SEQUENCE FOR PROCEDURE 3D

DROP	
Step	**Action**
1	Test the packaged-product according to the level in the Before You Begin Block. Follow the sequence in the table below.
2	All testing is now complete. Go to the Test Report Block.

Drop #	Packaged-Product Orientation
1	Bottom
2	Face 1
3	Face 2
4	Bottom
5	Face 1
6	Face 2

3D

Before You Begin
Report

TEST REPORT FOR PROCEDURE 3D

The packaged-product has satisfactorily passed the test if, upon examination, it meets the Product Damage Tolerance and Package Degradation Allowance.

ISTA Certified Testing Laboratories:

- Should file a test report on all ISTA Test Procedures or Projects conducted.
- Shall file a test report on all ISTA Test Procedures or Projects conducted to obtain Transit Tested Package Certification or Acknowledgement.

For additional information, refer to *Guidelines for Selecting and Using ISTA Procedures and Projects*.

ISTA Transit Tested Program

The ISTA Transit Tested Certification Mark as shown is a:

- registered certification mark **and**
- can only be used by license agreement **and**
- by a member of the International Safe Transit Association.

When a member prints this certification mark on a packaged-product with their license number they are showing their customer and the carrier that it has passed the requirements of ISTA preshipment testing.

In order to maintain its certified status and eligibility for identification with the TRANSIT TESTED Certification Mark, each packaged-product must be re-tested whenever a change is made in the:

- Product **or**
- Process **or**
- Package.

Changes in the product include changes in:

- Design **or**
- Size **or**
- Materials.

Changes in the process include changes in:

- Manufacturing **or**
- Assembly **or**
- Filling.

Changes in the package include changes in:

- Configuration **or**
- Dimensions **or**
- Weight **or**
- Materials **or**
- Components.

As a quality control procedure, packaged-products should be re-tested frequently, for example, yearly.

This Test Procedure is published by:
International Safe Transit Association
1400 Abbott Road, Suite 160, East Lansing, Mi 48823-1900 USA

Order Information: Additional copies of this Test Procedure, the ISTA RESOURCE BOOK (in print or on CD ROM) may be ordered by contacting ISTA at 517.333.3437 or by downloading an order form at www.ista.org

Appendix B

ISTA Procedure 3C

Packaged-Products for Parcel Delivery System Shipment 150 lb (68 kg) or Less

3C 2004

ISTA 3 Series General Simulation Performance Test Procedure

ISTA, Your Alliance in Transport Packaging, is the world leader in Performance Tests for Packaged-Products.

ISTA 3 Series tests are advanced tests.

- They challenge the capability of the package and product to withstand transport hazards, but
- They use general simulation of actual transport hazards, and
- They do not necessarily comply with carrier packaging regulations.

When properly applied, ISTA procedures will provide tangible benefits of:

- Shortened packaged development time and confidence in product launch
- Protection of products and profits with reduced damage and product loss
- Economically balanced distribution costs
- Customer satisfaction and continued business.

There are three sections: Overview, Testing and Report

- Overview provides the general knowledge required before going into the testing laboratory and
- Testing presents the specific instructions to do the testing in the laboratory and
- Report indicates what data shall be recorded to submit a test report to ISTA.

Two systems of weights and measures are presented in ISTA test procedures. They are the English system (Inch-Pound) and the international system SI (Metric). Inch-Pound units are shown first with Metric units in brackets, except in some table where they are shown separately.

- Either system may be used as the unit of measure (standard units), but
- The standard units chosen shall be used consistently throughout the procedure.
- Units are converted to two significant figures and
- Not exact equivalents.

VERY IMPORTANT: The entire document shall be read and understood before proceeding with a test.

OVERVIEW OF PROCEDURE 3C

Preface

Test Procedure 3C is a general simulation test for individual packaged-products shipped through a parcel delivery system.

- It can be used to evaluate the protective performance of packaged-products related to vibrations, shocks andotherstresses normally encountered during handling and transportation in a parcel delivery system.
- The test levels are based on general data and may not represent any specific distribution system.
- The package and product are considered together and not separately.
- Some conditions of transit, such as moisture, pressure or unusual handling, may not be covered.

Other ISTA Procedures may be appropriate for different conditions or to meet different objectives.

Specific suggestions:

- For small packaged-products 12 x 12 x 3 inches (310 x 310 x 80 mm) and/or 10 lb (4.5 kg) or less, use ISTA Test Procedure 3D and not 3C.
- For elongated packaged-products use ISTA Partial-Simulation Performance Test Procedure 2E and not 3C.
  Elongated shall be defined any packaged-product where:
  - The packages longest dimension is 36 inches (910 mm) or greater and
  - both of the packages other dimensions are each 20 percent or less of that of the longest dimension.
- For flat packaged-products use ISTA Partial-Simulation Performance Test Procedure 2D and not 3C.
  Flat shall be defined any packaged-product where:
  - The packages shortest dimension is 8 inches (200 mm) or less and
  - The packages next shortest dimension is four (4) or more times larger than the shortest dimensions.
  - Refer to *Guidelines for Selecting and Using ISTA Procedures and Projects* for additional information.

3C

OVERVIEW OF PROCEDURE 3C

Test Procedure 3C covers testing of individual packaged-products weighing 150 pounds (68 kg) or less when prepared for shipment via a parcel delivery service.

Product Damage Tolerance and Degradation Allowance

The shipper shall determine the following prior to testing:
- What constitutes damage to the product and
- what damage tolerance level is allowable, if any, and
- the correct methodology to determine product condition at the conclusion of the test and
- the acceptable package condition at the conclusion of the test.

For additional information on this determination process refer to *Guidelines for Selecting and Using ISTA Procedures and Projects*.

Samples

Samples should be the untested actual package and product, but if one or both are not available, the substitutes shall be as identical as possible to actual items.

Number of samples required:
One sample is required for the tests in this procedure but three are recommended.

Replicate Testing Recommended:
To permit an adequate determination of representative performance of the packaged-product, ISTA:
- Requires the procedure to be performed one time, but
- Recommends performing the procedure five or more times using new samples with each test.

NOTE:
Packages that have already been subjected to the rigors of transportation cannot be assumed to represent standard conditions. In order to insure testing in perfect condition, products and packages shipped to certified laboratories for testing must be:
- over-packaged for shipment to the laboratory or
- repackaged in new packaging at the laboratory.

Test Sequence

The tests shall be performed on each test sample in the sequence indicated in the following table:

Sequence #	Test Category	Test Type	Test Level	For ISTA Certification
1	Atmospheric Preconditioning	Temperature and Humidity	Ambient	Required
2	Atmospheric Conditioning	Controlled Temperature and Humidity	Temperature and Humidity Chosen from chart	Optional
3	Shock	Drop	Height varies with packaged-product weight	Required
4	Vibration	Under Dynamic Load Random	Calculated or maximum Top-Load and overall G_{rms} level of .53	Required
5	Shock	Drop	Height varies with packaged-product weight. Includes drop on hazard	Required

3C

EQUIPMENT REQUIRED FOR PROCEDURE 3C

Equipment Required **Atmospheric**

Atmospheric Conditioning:

- Humidity recording apparatus complying with of the apparatus section of ASTM D 4332-01.
- Temperature recording apparatus complying with the apparatus section of ASTM D 4332-01.

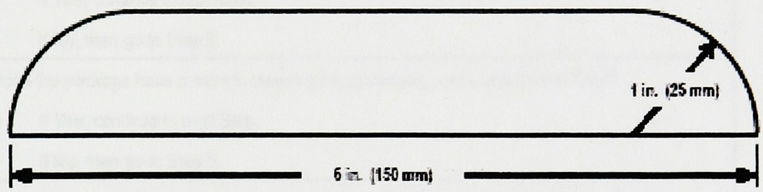
Optional Atmospheric Conditioning

- Chamber and Control apparatus complying with the apparatus section of ASTM D 4332-01.

Equipment Required Shock

Free Fall Drop Test:

- Free Fall Drop Test System complying with of the apparatus section of ASTM D 5276-98.
- Hazard made of hardwood or steel. The hazard shall be 1 inch in height x 6 inches in width (25 mm x 150 mm) and at least 8 inches (200 mm) longer than the second shortest package dimension of the Length, width and height. The long top edges of the hazard shall be rounded to a radius of 1 inch ± 0.0625 inch (25 mm ±0.02mm).



Equipment Required Vibration

Random Vibration Test:

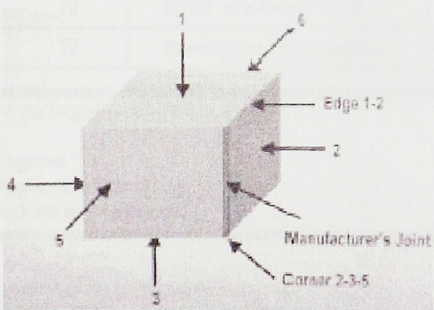
- Random Vibration Test System complying with the apparatus section of ASTM D 4728-01.
- Top-Load apparatus of one, two or three separate loading systems.

3C

Identification of Faces, Edges and Corners

BEFORE YOU BEGIN PROCEDURE 3C

Prior to beginning the tests identify the faces, edges and corners according to the procedure below.

Step	Action
1	Place the packaged-product so the package is in its most stable orientation (largest face down) with the label facing up or toward you.
2	Does the packaged-product have only six faces (2 sides, 2 ends, top and bottom)? • **If Yes**, then go to Step 5. • **If No**, continue to next Step.
3	Develop a method to identify each face, edge and corner and document with a diagram.
4	Go to the next Block.
5	Is the package a corrugated container? • **If Yes**, continue to next Step. • **If No**, then go to Step 8.
6	Does the package have a manufacturer's joint connecting a side and an end face? • **If Yes**, continue to next Step. • **If No**, then go to Step 8.
7	Turn the packaged-product so that you are looking directly at a face with the manufacturer's joint on the observer's right and go to Step 9.
8	Position one of the smallest width faces of the packaged-product directly in front of you.
9	**Identify faces** according to the diagram below. 
10	**Identify edges** using the numbers of the two faces forming that edge. Example: Edge 1-2 is the edge formed by face 1 and face 2 of the packaged-product.
11	**Identify corners** using the numbers of the three faces that meet to form that corner. Example: Corner 2-3-5 is the corner formed by face 2, face 3, and face 5 of the packaged-product.
12	Go to next Block.

3C

Packaged-Product Weight and Size Measurement

BEFORE YOU BEGIN PROCEDURE 3C

You shall know the packaged-products:

- gross weight in pounds (kg), and
- outside dimensions of Length, Width and Height (L x W x H) in inches (mm or m)

Before You Begin Atmospheric Conditioning

Required Preconditioning:
The packaged-product should be stored prior to climate conditioning at laboratory ambient temperature and humidity for twelve (12) hours.

Optional Conditioning Recommended: After the required precondition
To permit an adequate determination of packaged-product performance at anticipated atmospheric limits and where it is known that the atmospheric extremes are detrimental to the product, ISTA

- **Requires** the highest temperature and humidity limits shall be used, but
- **Recommends** that both the highest and lowest atmospheric conditions be used.

A separate 3C test sequence should be conducted following each atmospheric condition selected from the table below:

Anticipated Conditions	Time in Hours	Temperature in °C ±2°C (°F ±4°F)		Humidity in %
Frozen or winter ambient	72	-29°C	(-20°	uncontrolled RH
Refrigerated packages	72	5°C	(40°	85% RH ±5%
Controlled temperature	72	23°C	(72°	85% RH ±5%
Tropical (Wet) climate	72	38°C	(100°	85% RH ±5%
Tropical (Wet) then desert (Dry):	72 then 6	38°C	(100°	85% RH ±5% then 30% RH ±5%
Desert or summer ambient	72	50°C	(120°	uncontrolled RH
User Defined High Limit	72	Based upon known conditions		Known conditions
User Defined Low Limit	72	Based upon known conditions		Known conditions
User Defined Cycle	72	Based upon known conditions		Known conditions

Before You Begin Shock Testing

The test drop height varies for packaged-products that weigh:

- less than (<) 50 lb. (23 kg),
- 50 lb. (23 kg) to 100 lb. (45 kg) and
- greater than (>) 100 lb. (45 kg) up to 150 lb. (68 kg).

The drop height also varies with the drop sequence.

Before You Begin Vibration Under Dynamic Load Testing

CAUTION:
A restraining device or devices shall be used with the vibration test system to:

- Prevent the Top-Load from moving off the package being tested and
- Prevent the test specimen from moving off the platform and
- Maintain test orientation of the stack, but
- The device or devices shall not restrict the vertical motion of the test specimen during the test

The packaged-product is tested

- in all three axis
- with a Top-Load calculated for the face 3 down axis

Continued

3C

Before You Begin Vibration Under Dynamic Load Testing

BEFORE YOU BEGIN PROCEDURE 3C

Top-Load

The Top-Load is to simulate 12-pounds/cubic foot (190 kg/m³) of assorted freight on top of a floor loaded shipping unit in a 108-inch (2.7 m) trailer.

The Top-Load apparatus shall be

- Larger than the test specimen, and
- Shall distribute the calculated Top-Load (TL) evenly over the test specimen.

A possible Top-Load apparatus system would be one or more containers with the following specifications:

- RSC – style corrugated container and
- 33 lb. (161 g/m^2) maximum basis weight corrugated medium and
- 0.5 in. (13 mm) minimum thickness plywood pieces covering the entire area of the bottom inside flaps of the container, and
- Plastic bags of sand.

Note:
To convert basis weight in gm/m² (Metric) to basis weight in lb/1000ft² (English), divide by 4.885.

Dynamic Top-Load

The Top-Load is to simulate the effect of 12 pounds per cubic foot (lb/ft³) [200 kilograms per cubic meter (kg/m³)] of assorted freight on top of a floor loaded shipping unit in an over-the-road trailer with an inside height of 108 in. (2.7 m).

The Dynamic Top-Load for each axis is determined by

- Starting with the possible height within a tractor trailer of 108 inches (2.7 meters) and
- Subtracting the vertical dimension of the package in the axis of the test and
- Taking the resultant and multiply it by each dimension of the other two axes, and
- Multiplying that resultant by the Loading Factor and
- That will be the Top-Load in pounds (kilograms) for the vibration test, **unless**
- That value is greater than 350 pounds (160 kilograms), **then**
- Use a Top-Load of 350 pounds (160 kilograms).

The Loading Factor has been determined by empirical testing that resulted in correlation between damage in the test lab and damage in the field. The Loading Factor is calculated by

- Starting with the estimated average density of a trailer of parcel packages at 12 lb/ft³ (200 kg/m³) and
- For English units, divide 12 lb/ ft³ by (1728 in³/ft³) to get .007 lb/in³ or
- For Metric units use 200 kg/m³ and
- Multiply 0.007 lb/in³ (200 kg/m³) by 0.5 to get the Loading Factor of .0035 lb/in³ (100 kg/m³).

Note:
This is a major change from previous versions of 3C. It reduces the Top-Load by 50%.

Continued

3C

Before You Begin Vibration Under Dynamic Load Testing Continued

BEFORE YOU BEGIN PROCEDURE 3C

Familiarity with the following formula is required:

Top-Load Formulas TL		English Units in Inches	Metric Units in Meters
Top-Load (TL–H) with face 3 dow	TL1	(108 – H) x L x W x 0.0035	(2.7 – H) x L x W x 100
Top-Load (TL–L) with face 4 dow	TL2	(108 – L) x H x W x 0.0035	(2.7 – L) x H x W x 100
Top-Load (TL–W) with face 5 down	TL3	(108 – W) x H x L x 0.0035	(2.7 – W) x H x L x 100

Where			
TL	Total Weight of the Top-Load Package	Pounds	Kilograms
2.7 m (108 in.)	Height of typical trailer	Inches	Meters
H	Height of shipping unit	Inches	Meters
L	Length of shipping unit	Inches	Meters
W	Width of shipping unit	Inches	Meters
Loading Factor	50% of the Average density of freight	0.0035 lb/in³	100 kg/m³

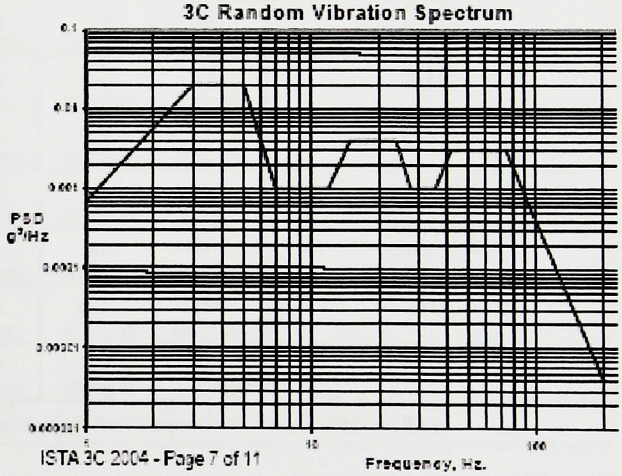
Determine the Maximum Top-Load weight with the following Table

Maximum Top-Load weight (TL) for any Axis	English Units	Metric Units
Determine the Top-Load weight to be used for each axis by comparing the calculated TL against the following statements.		
IF the calculated Top-Load for an axis is ...	**THEN ...**	
350 lb (160 kg) or Less	Use the calculated Top-Load (TL) for that axis.	
Greater than 350 lb (160 kg)	Use 350 lb (160 kg) as the Top-Load (TL)	

The following breakpoints are for an over-the-road trailer typical for parcel delivery movement and shall be programmed into the vibration controller to produce the acceleration versus frequency profile (spectrum) below with an overall G_{rms} level of 0.53:

Frequency (Hz)	PSD Level, g²/Hz
1	0.0007
3	0.02
5	0.02
7	0.001
12	0.001
15	0.004
24	0.004
28	0.001
36	0.001
42	0.003
75	0.003
200	0.000004

3C Random Vibration Spectrum



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3C

Atmospheric Conditioning Test Block

First Shock Test Block

TEST SEQUENCE FOR PROCEDURE 3C

The test blocks that follow contain tables that indicate the required steps for each test in the procedure.

TEMPERATURE AND HUMIDITY

Step	Action
1	The packaged-product should be stored at laboratory ambient temperature and humidity for twelve (12) hours.
2	Is optional conditioning going to be performed? • If Yes, go to Step 6. • If No, go to the next Step.
3	Record the ambient laboratory temperature and humidity when testing starts.
4	At the end of all testing record temperature and humidity.
5	Go to the next First Shock Test Block.
6	Select an anticipated condition from the Before You Begin Block.
7	Check the conditioning apparatus to insure that the temperature and humidity are at the required levels.
8	Place the packaged-product in the conditioning.
9	At the completion of the required conditioning time remove the packaged-product from the conditioning apparatus.
10	Record the ambient laboratory temperature and humidity when testing starts. Go to the First Shock Test Block and perform the remaining test sequence as quickly as possible.

DROP

Step	Action
1	Follow the table below to determine the height and orientation for the first 7 drops.
2	Shock test is now complete. Go to the Vibration Under Dynamic Load Test Block.

Drop Number	< 50 lb (23 kg)	50-100 lb (23-45 kg)	> 100–150 lb (45-68 kg)	Test Specimen
1	15 in. (380 mm)	12 in. (310 mm)	9 in. (230 mm)	edge 3-4
2	15 in. (380 mm)	12 in. (310 mm)	9 in. (230 mm)	edge 3-5
3	15 in. (380 mm)	12 in. (310 mm)	9 in. (230 mm)	edge 4-5
4	15 in. (380 mm)	12 in. (310 mm)	9 in. (230 mm)	corner 3-4-5
5	15 in. (380 mm)	12 in. (310 mm)	9 in. (230 mm)	corner 2-3-5
6	30 in. (760 mm)	24 in. (610 mm)	18 in. (460 mm)	face 3
7	15 in. (380 mm)	12 in. (310 mm)	9 in. (230 mm)	face 3

3C

Vibration Under Dynamic Load Test Block

TEST SEQUENCE FOR PROCEDURE 3C

DYNAMIC LOAD AND RANDOM	
Step	**Action**
1	Complete the following test sequence for each type of package that has a check in the box:
2	Place the packaged-product on the center of the vibration table so that face-3 rests on the platform.
3	Place the Dynamic Top-Load package as determined in the Before You Begin Vibration Under Dynamic Load Testing Block for TL-H on top of the test specimen.
4	Using some form of column stack fixturing to make sure that the stack maintains its orientation without restricting the vertical motion of the Top-Load package or the test specimen.
5	Start the vibration machine to produce the Over-the-Road random vibration spectrum indicated in the Before You Begin Block.
6	After 60 minutes, stop the vibration testing and remove the Dynamic Top-Load package(s).
7	Inspection of the packaged-product for visible damage is allowed, provided inspection does not alter, in any way, the current condition of the package or the condition or position of the product(s).
8	Rotate the test specimen so that face-4 rests on the center of the vibration table platform.
9	Place the Dynamic Top-Load package as determined in the Before You Begin Vibration Under Dynamic Load Testing Block for TL-L on top of the test specimen.
10	Using some form of column stack fixturing to make sure that the stack maintains it's orientation without restricting the vertical motion of the Top-Load package or the test specimen.
11	Start the vibration machine to produce the Over-the-Road random vibration spectrum indicated in the Before You Begin Block.
12	After 30 minutes, stop the vibration testing and remove the Dynamic Top-Load package(s).
13	Inspection of the packaged-product for visible damage is allowed, provided inspection does not alter, in any way, the current condition of the package or the condition or position of the product(s).
14	Rotate the test specimen so that face-5 rests on the center of the vibration table platform.
15	Place the Dynamic Top-Load package as determined in the Before You Begin Vibration Under Dynamic Load Testing Block for TL-W on top of the test specimen.
16	Using some form of column stack fixturing to make sure that the stack maintains it's orientation without restricting the vertical motion of the Top-Load package or the test specimen.
17	Start the vibration machine to produce the Over-the-Road random vibration spectrum indicated in the Before You Begin Block.
18	After the completion of 30 minutes, stop the vibration testing and remove the Dynamic Top-Load package(s).
19	Inspection of the packaged-product for visible damage is allowed, provided inspection does not alter, in any way, the current condition of the package or the condition or position of the product(s).
20	Vibration testing is now complete. Go to the appropriate Second Shock Test Block.

3C

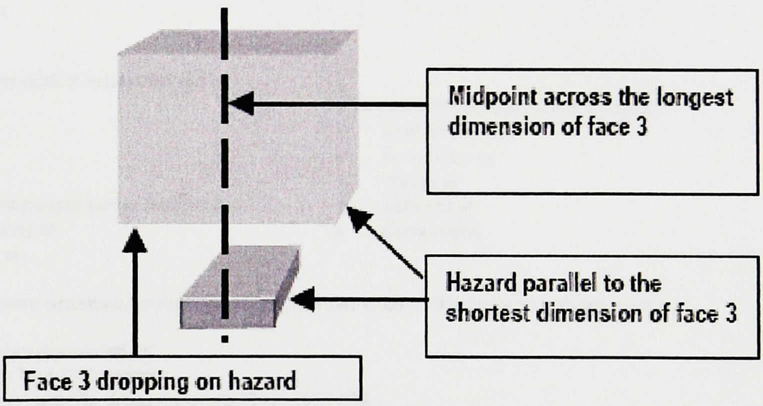
Second Shock Test Block

TEST SEQUENCE FOR PROCEDURE 3C

DROP

Step	Action
1	Follow the table below to determine the height and orientation for the final set of 8 drops.

Drop Number	< 50 lb (23 kg)	50-100 lb (23-45 kg)	> 100–150 lb (45-68 kg)	Test Specimen
1	15 in. (380 mm)	12 in. (310 mm)	9 in. (230 mm)	edge 3-4
2	15 in. (380 mm)	12 in. (310 mm)	9 in. (230 mm)	edge 3-6
3	15 in. (380 mm)	12 in. (310 mm)	9 in. (230 mm)	edge 3-5
4	15 in. (380 mm)	12 in. (310 mm)	9 in. (230 mm)	corner 3-4-6
5	15 in. (380 mm)	12 in. (310 mm)	9 in. (230 mm)	corner 1-2-6
6	15 in. (380 mm)	12 in. (310 mm)	9 in. (230 mm)	face 1
7	30 in. (760 mm)	24 in. (610 mm)	18 in. (460 mm)	face 4



For the next drop, the test specimen should strike the hazard midpoint across the longest dimension of the face and parallel to the shortest dimension of the face being impacted. The required drop distance is to the impact surface, not to the hazard. The diagram above shows this concept.

Drop 8	15 in. (380 mm)	12 in. (310 mm)	9 in. (230 mm)	face 3 on hazard

Step	Action
2	All testing is now complete. Go to the Test Report Block.

TEST REPORT FOR PROCEDURE 3C

The packaged-product has satisfactorily passed the test if, upon examination, it meets the Product Damage Tolerance and Package Degradation Allowance.

ISTA Certified Testing Laboratories:

- Should file a test report on all ISTA Test Procedures or Projects conducted.
- Shall file a test report on all ISTA Test Procedures or Projects conducted to obtain Transit Tested Package Certification or Acknowledgement.

For additional information, refer to *Guidelines for Selecting and Using ISTA Procedures and Projects.*

ISTA Transit Tested Program

TRANSIT TESTED

INTERNATIONAL SAFE TRANSIT ASSOCIATION

AAAAA

The ISTA Transit Tested Certification Mark as shown is a:

- registered certification mark and
- can only be used by license agreement and
- by a member of the International Safe Transit Association.

When a member prints this certification mark on a packaged-product with their license number they are showing their customer and the carrier that it has passed the requirements of ISTA preshipment testing.

In order to maintain its certified status and eligibility for identification with the TRANSIT TESTED Certification Mark, each packaged-product must be re-tested whenever a change is made in the:

- Product or
- Process or
- Package.

Changes in the product include changes in:

- Design or
- Size or
- Materials.

Changes in the process include changes in:

- Manufacturing or
- Assembly or
- Filling.

Changes in the package include changes in:

- Configuration or
- Dimensions or
- Weight or
- Materials or
- Components.

As a quality control procedure, packaged-products should be re-tested frequently, for example, yearly.

This Test Procedure is published by:
International Safe Transit Association
1400 Abbott Road, Suite 150, East Lansing, MI 48823-1900 USA

Order Information: Additional copies of this Test Procedure, the ISTA RESOURCE BOOK (in print or on CD ROM) may be ordered by contacting ISTA at 517.333.3437 or by downloading an order form at www.ista.org

Appendix C

UPS Drop Height Data

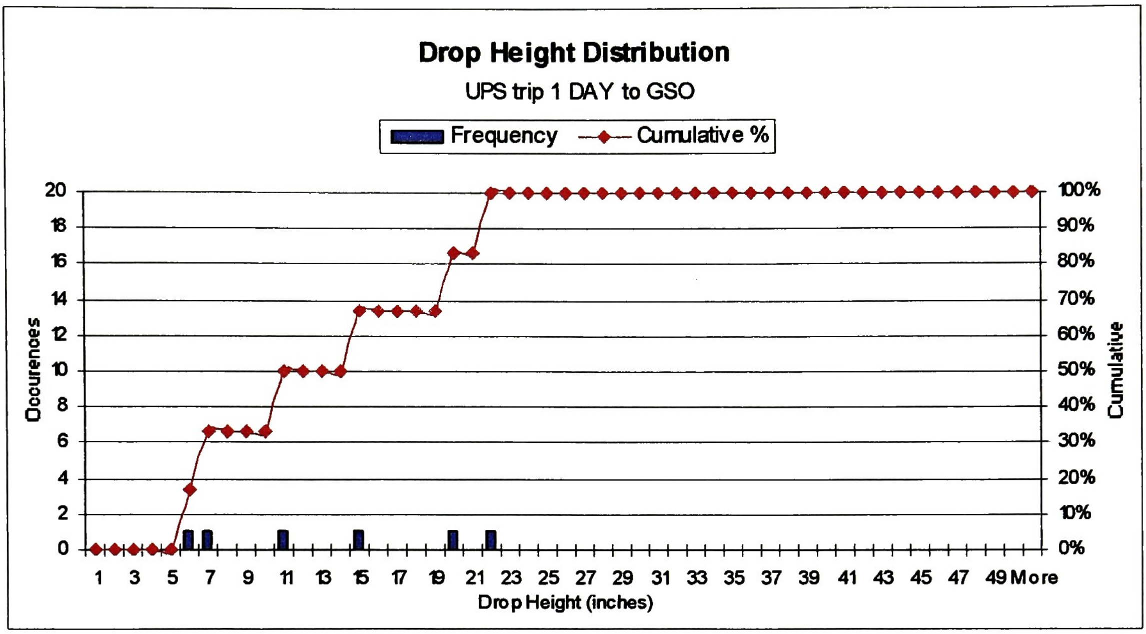


Figure 11. UPS trip 1 - DAY to GSO

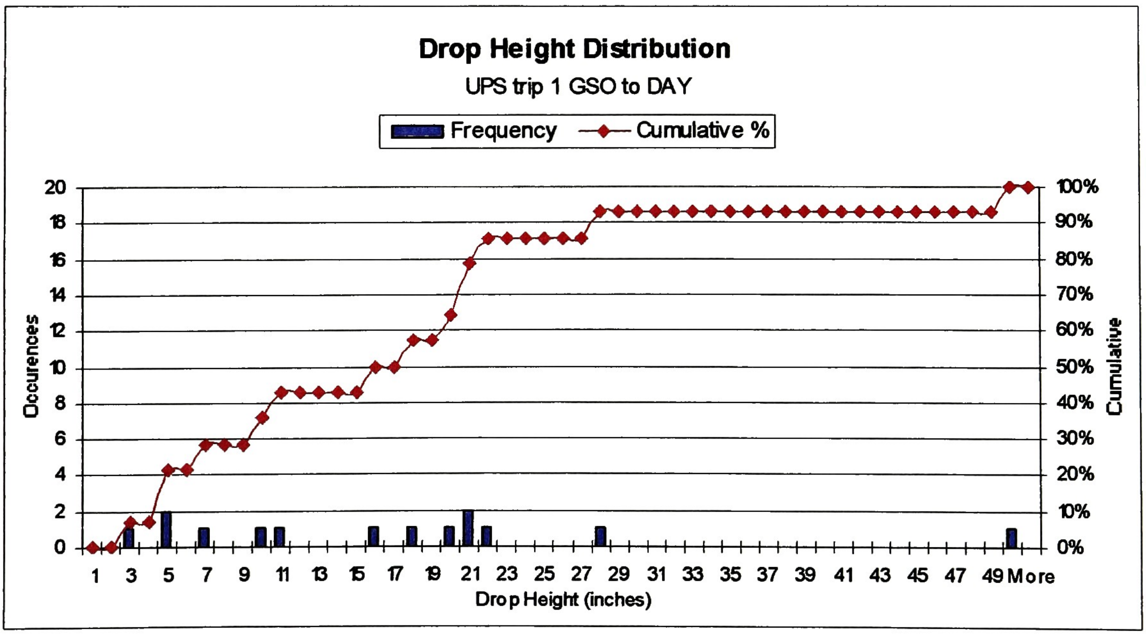


Figure 12. UPS trip 1 - GSO to DAY

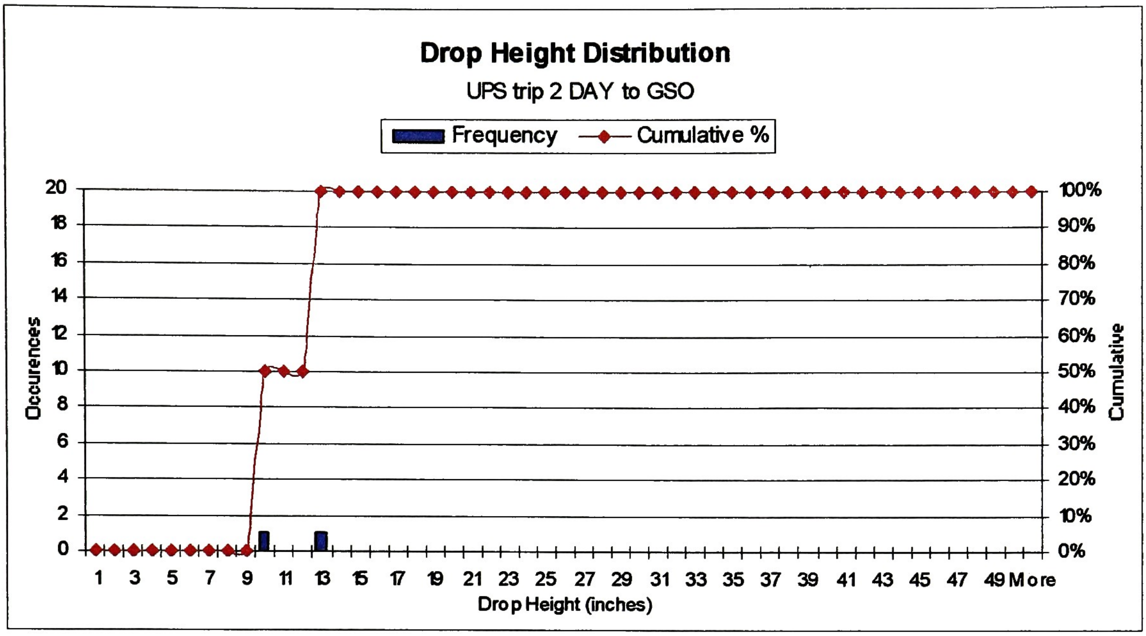


Figure 13. UPS trip 2 - DAY to GSO

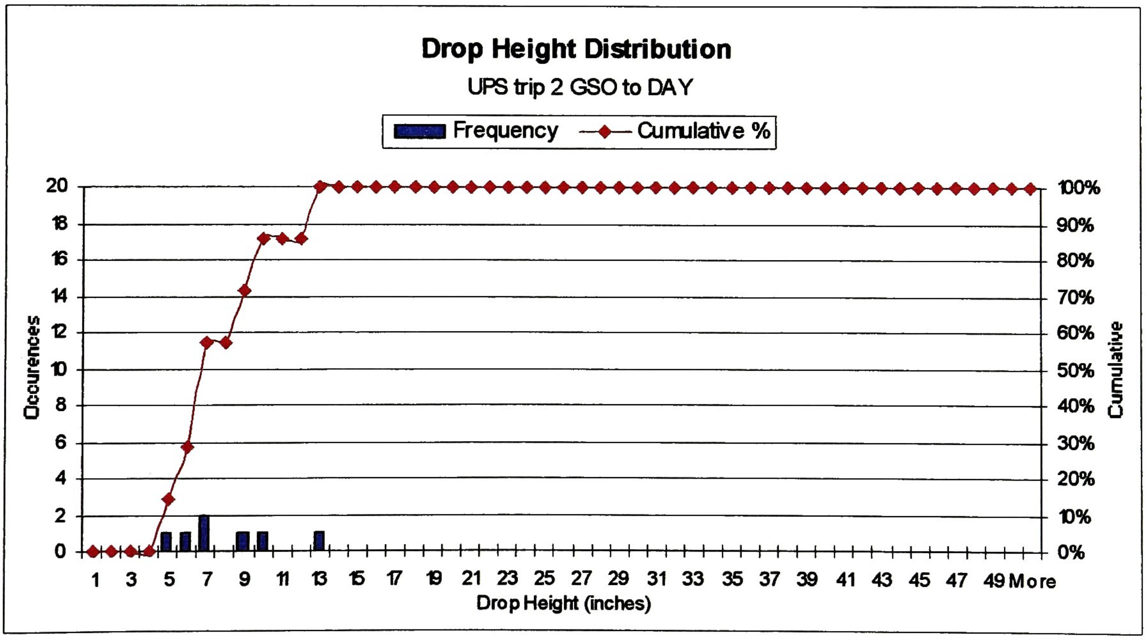


Figure 14. UPS trip 2 - GSO to DAY

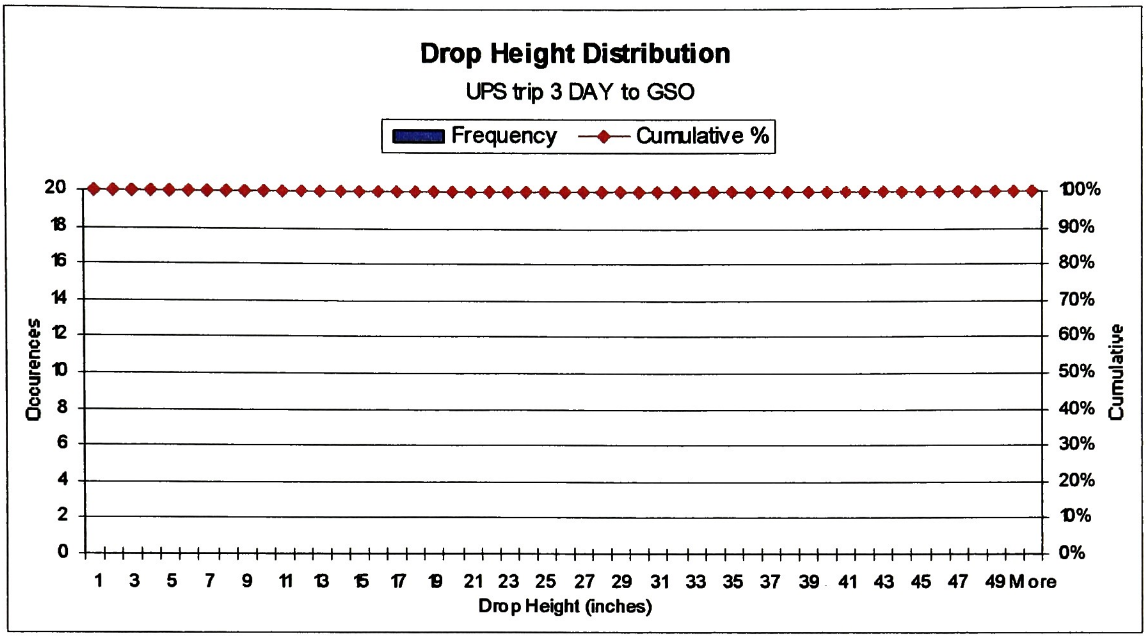


Figure 15. UPS trip 3 - DAY to GSO

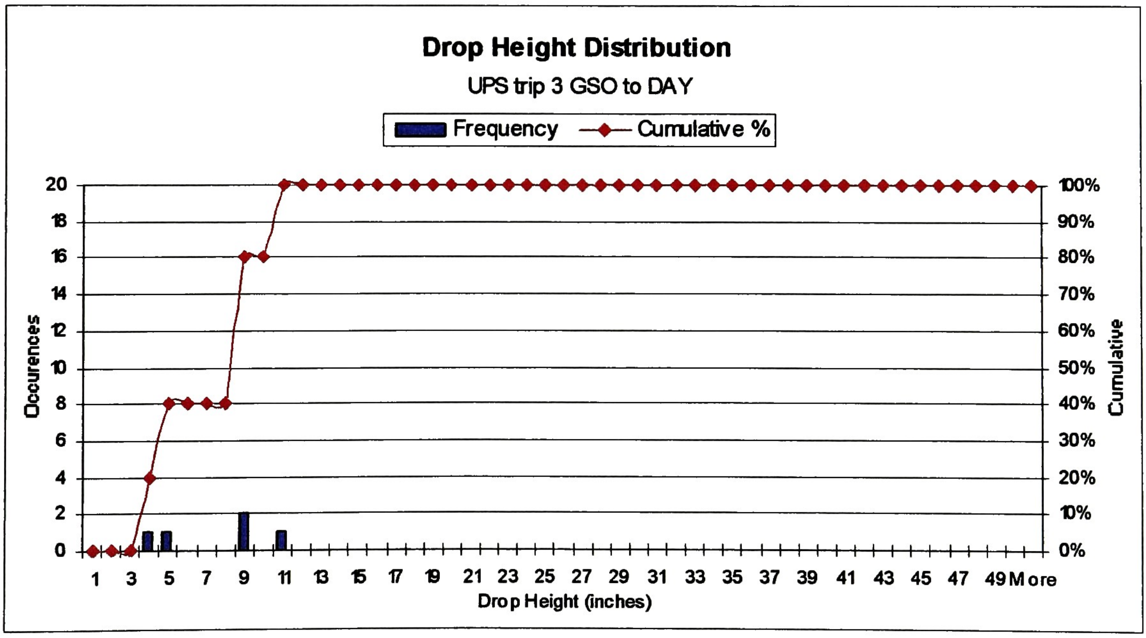


Figure 16. UPS trip 3 - GSO to DAY

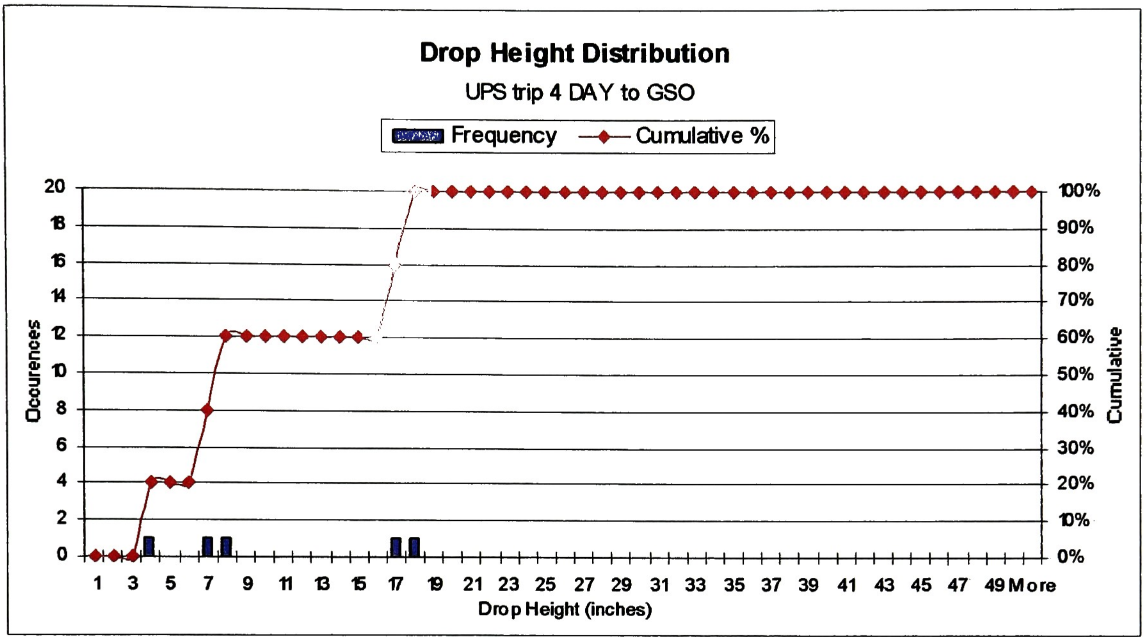


Figure 17. UPS trip 4 - DAY to GSO

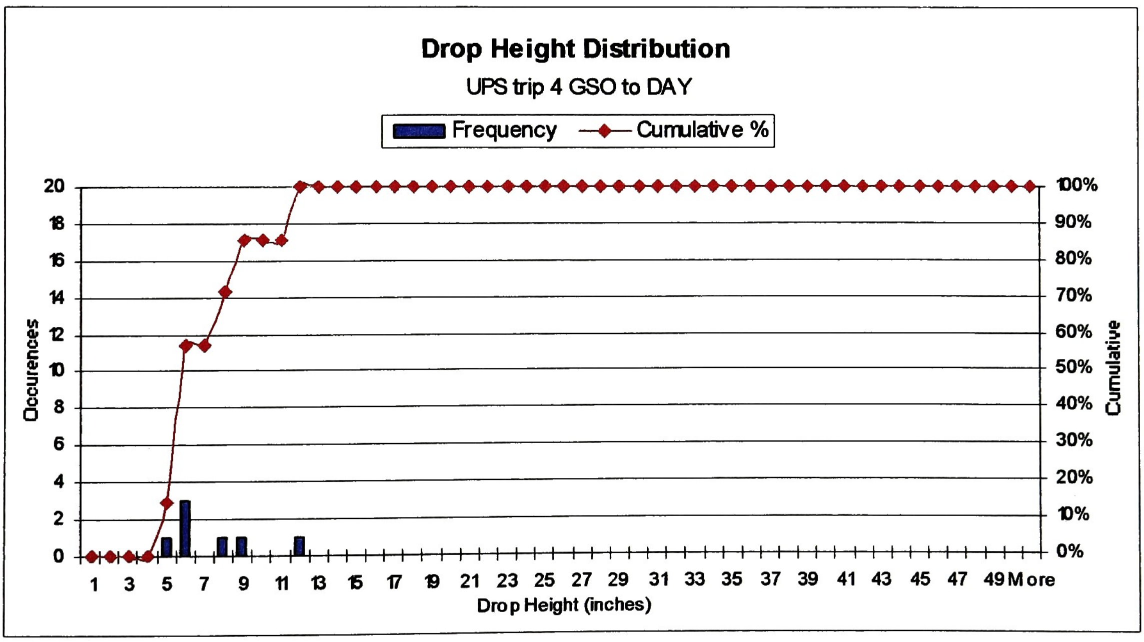


Figure 18. UPS trip 4 - GSO to DAY

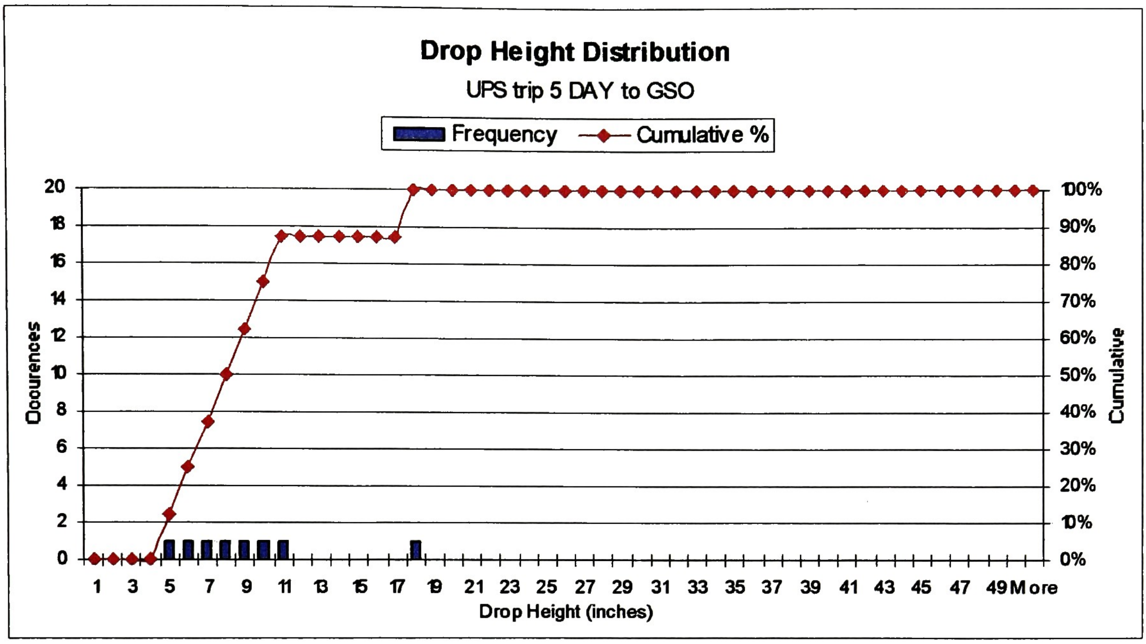


Figure 19. UPS trip 5 - DAY to GSO

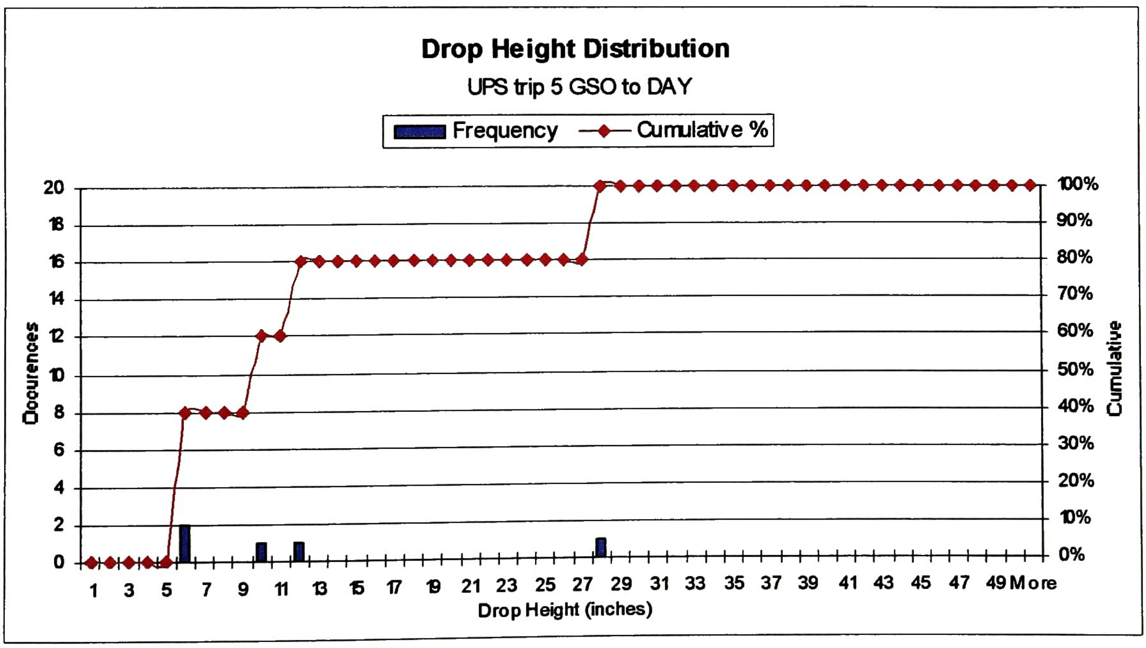


Figure 20. UPS trip 5 - GSO to DAY

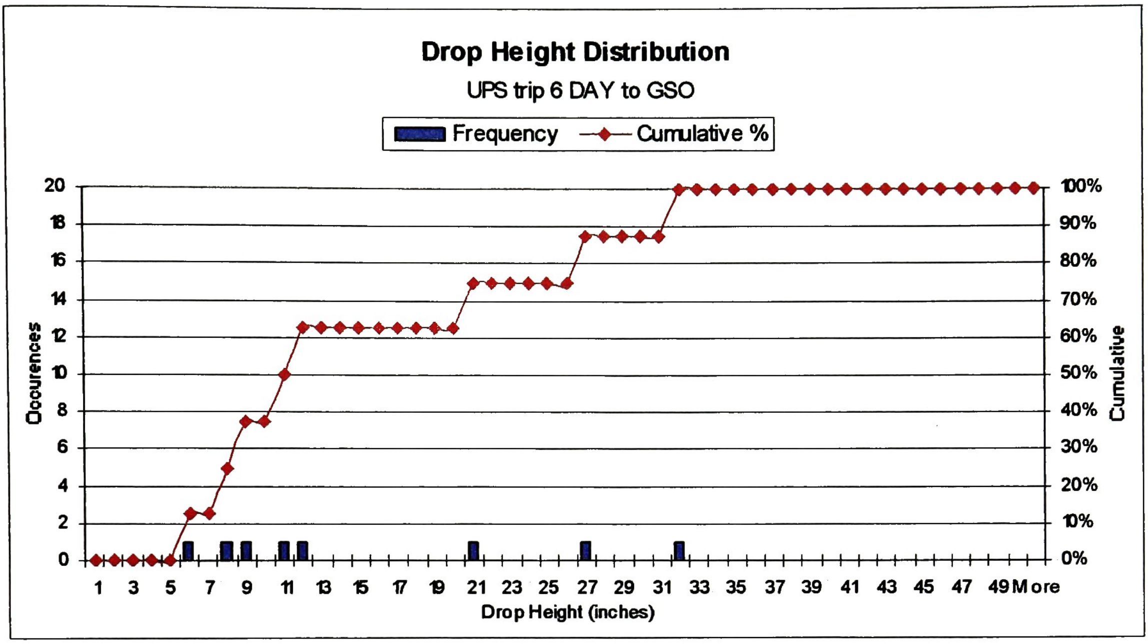


Figure 21. UPS trip 6 - DAY to GSO

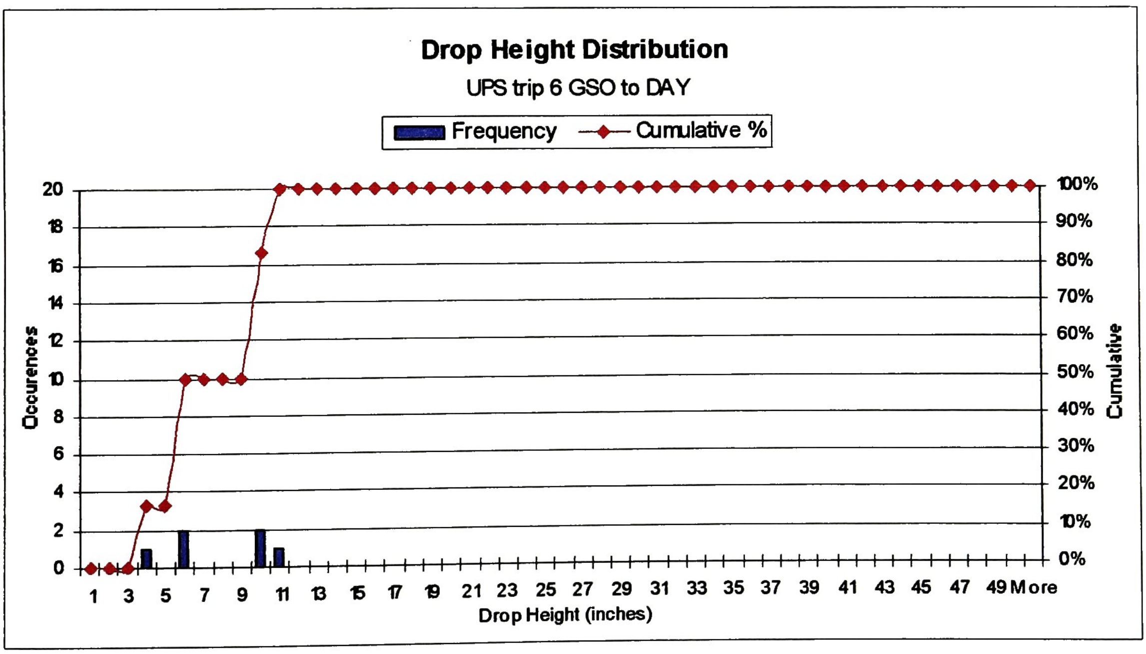


Figure 22. UPS trip 6 - GSO to DAY

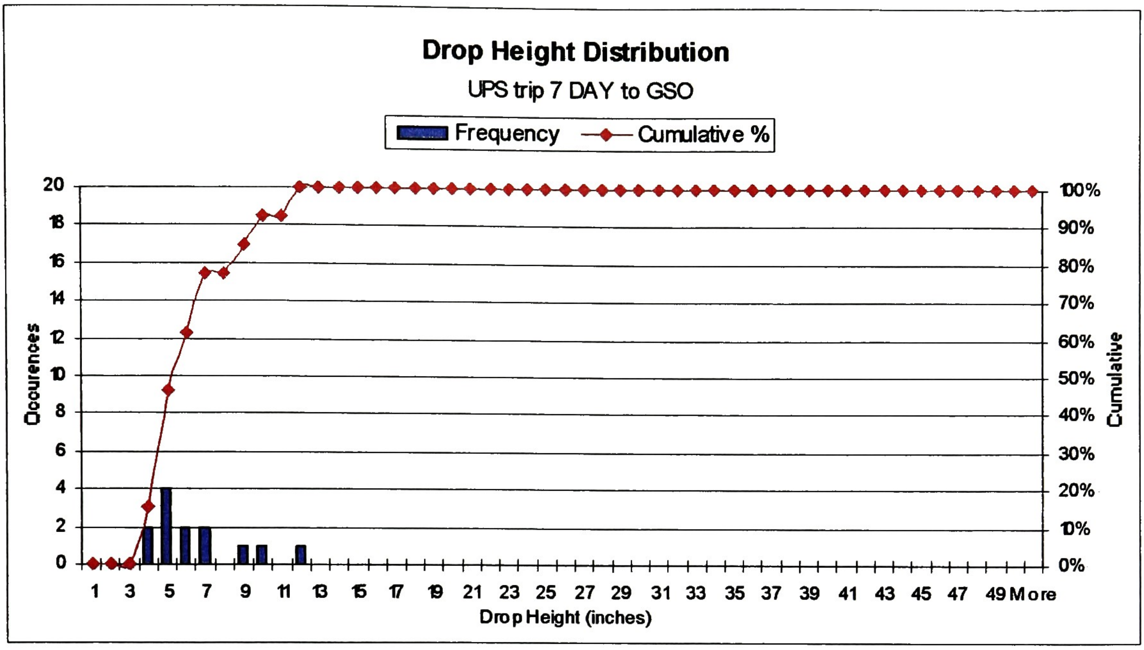


Figure 23. UPS trip 7 - DAY to GSO

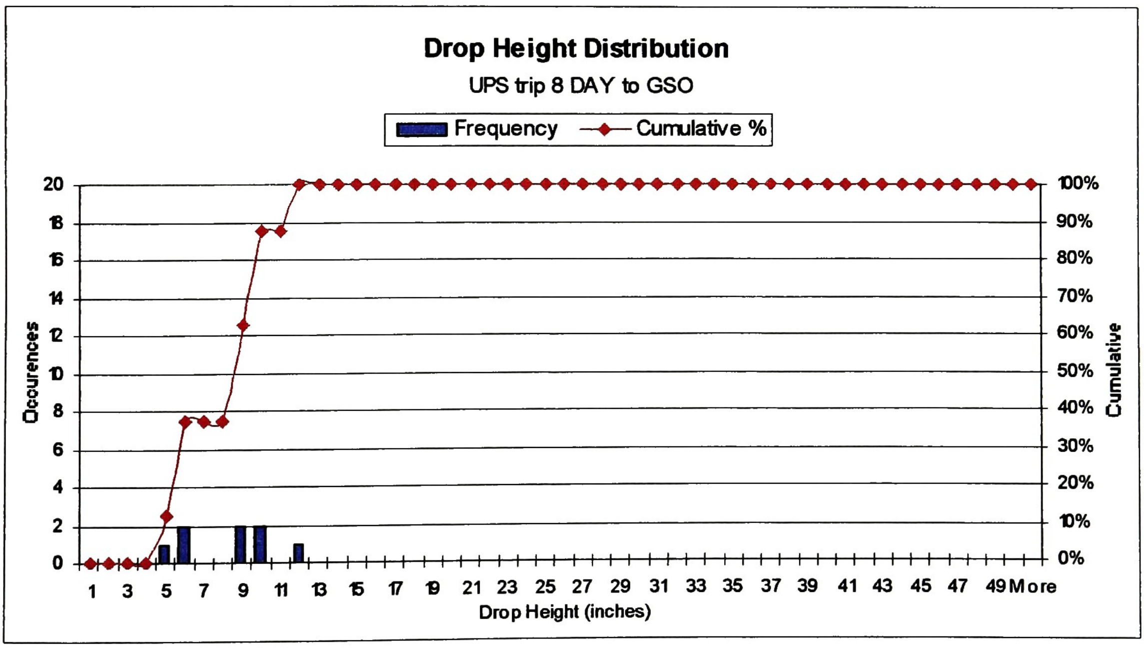


Figure 24. UPS trip 8 - DAY to GSO

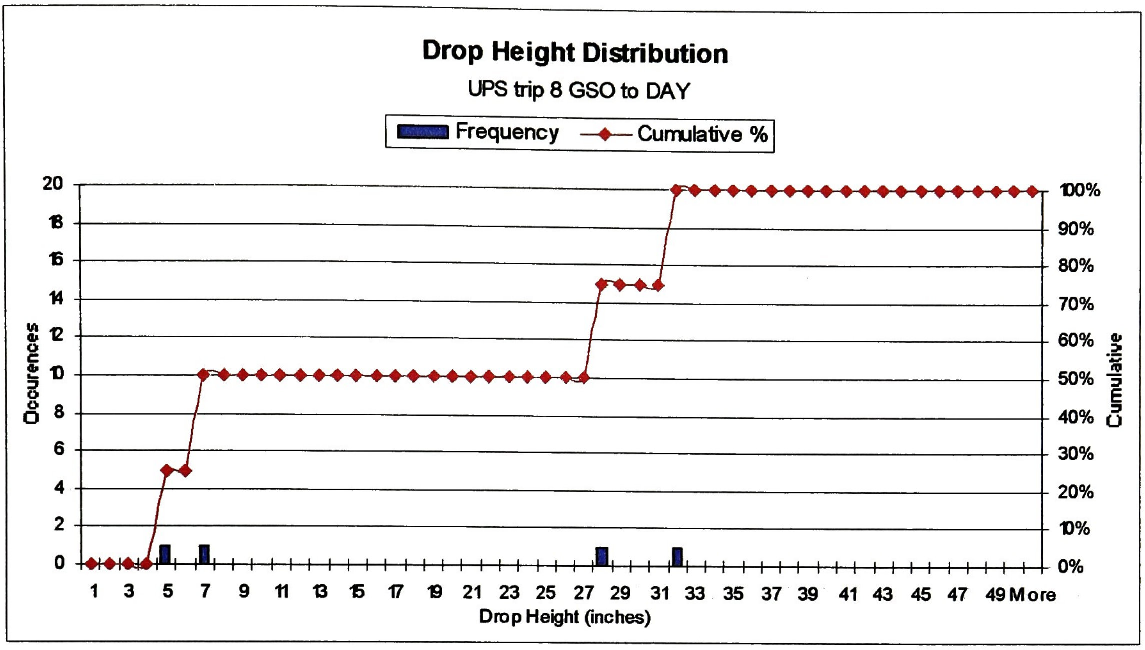


Figure 25. UPS trip 8 - GSO to DAY

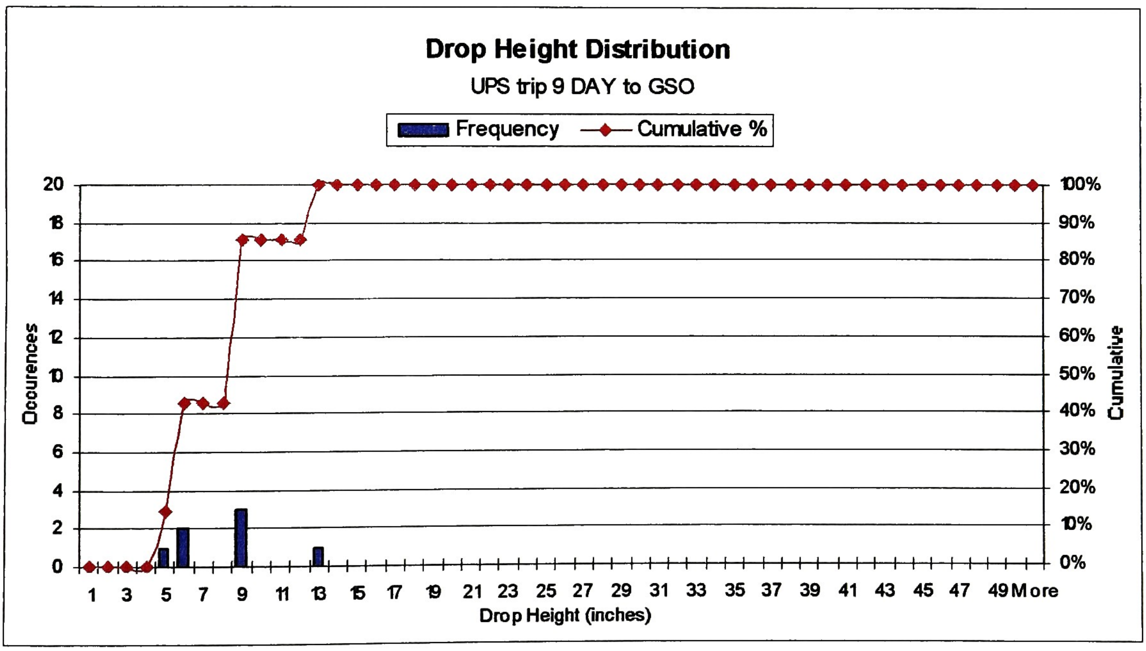


Figure 26. UPS trip 9 - DAY to GSO

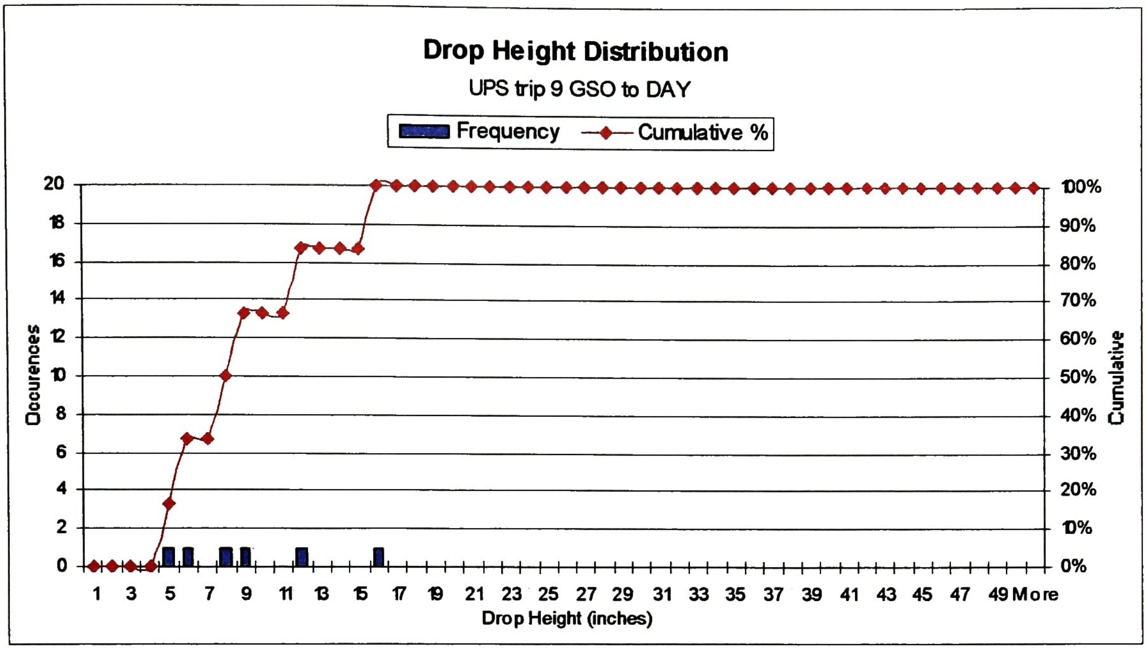


Figure 27. UPS trip 10 - GSO to DAY

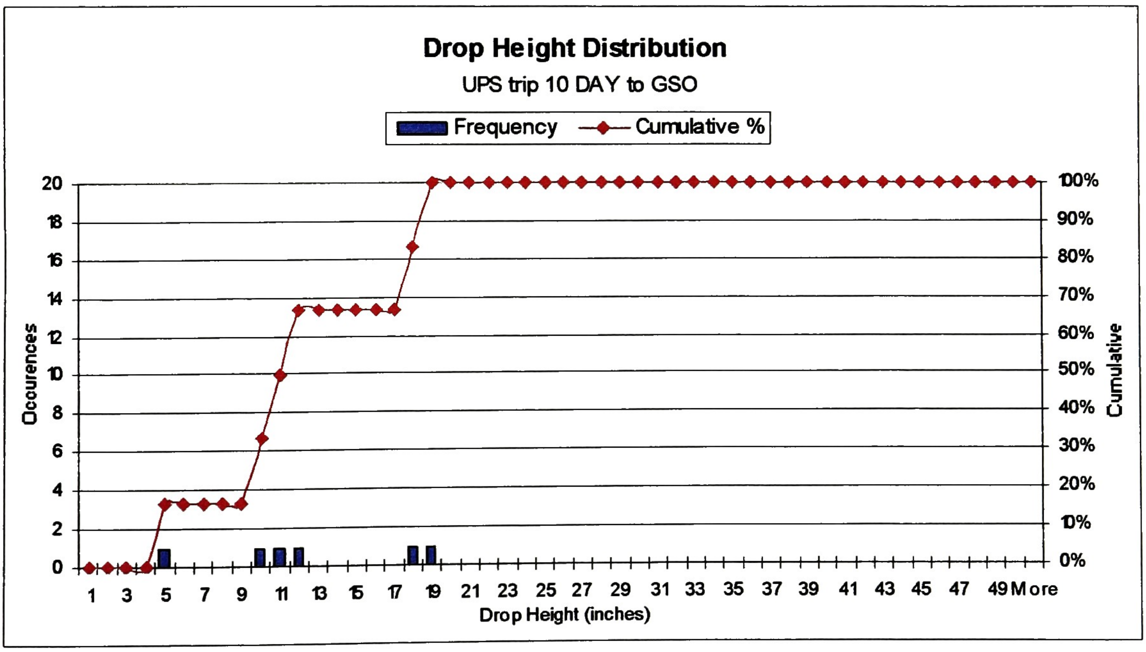


Figure 28. UPS trip 10 - DAY to GSO

Appendix D
FedEx Drop Height Data

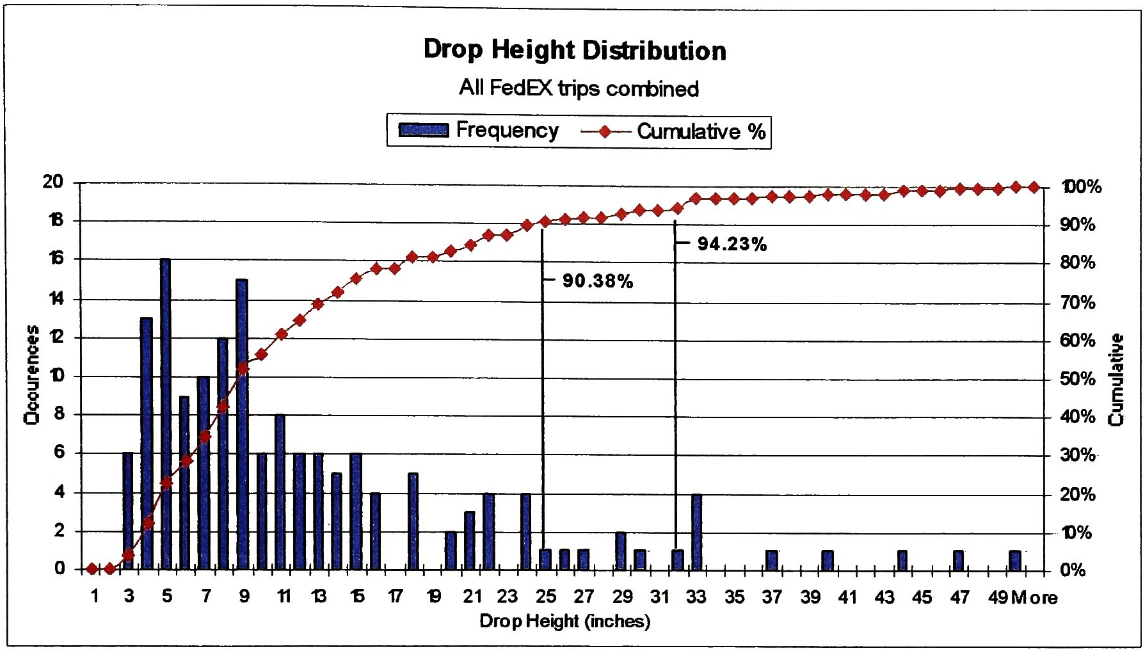


Figure 29. All FedEx Drops Combined

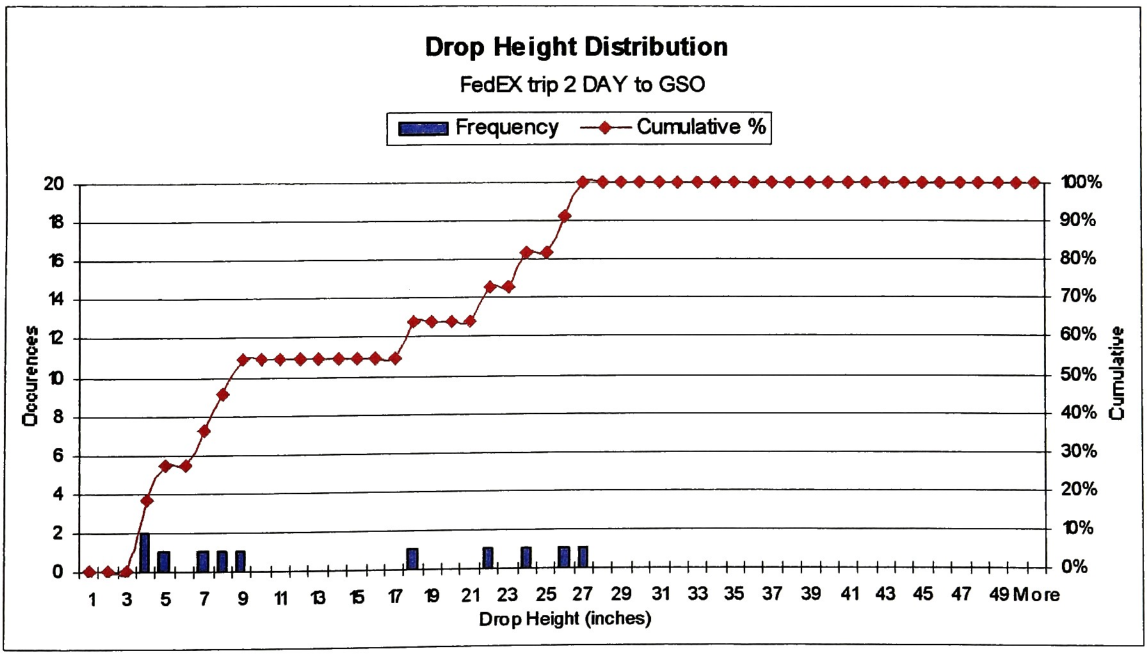


Figure 30. FedEx trip 2 - DAY to GSO

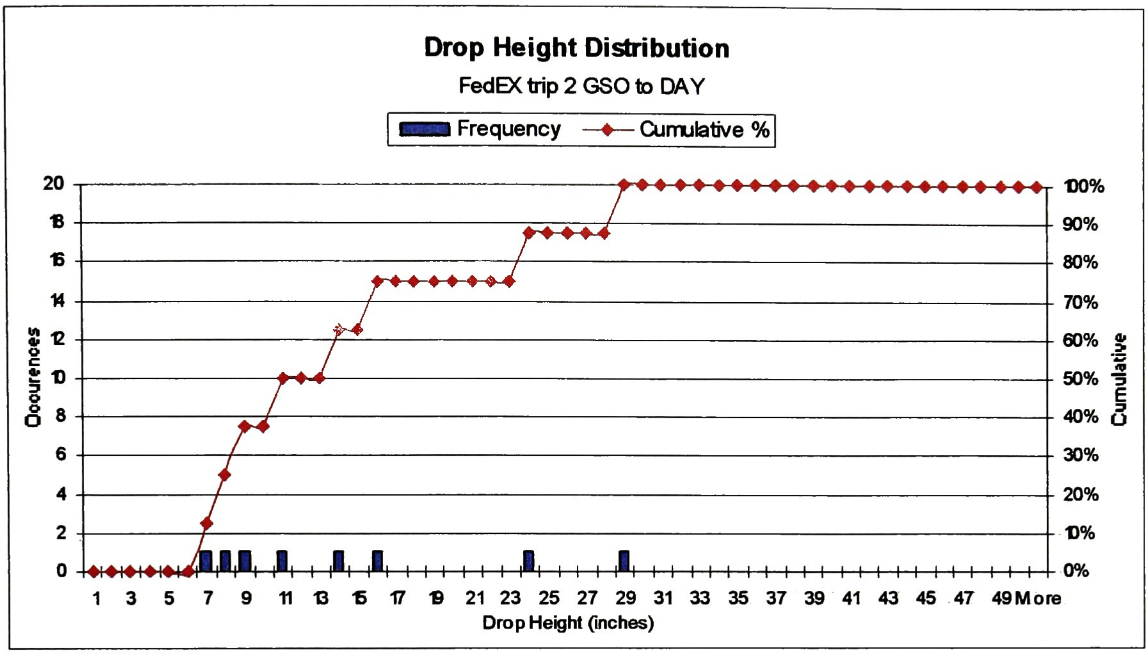


Figure 31. FedEx trip 2 - GSO to DAY

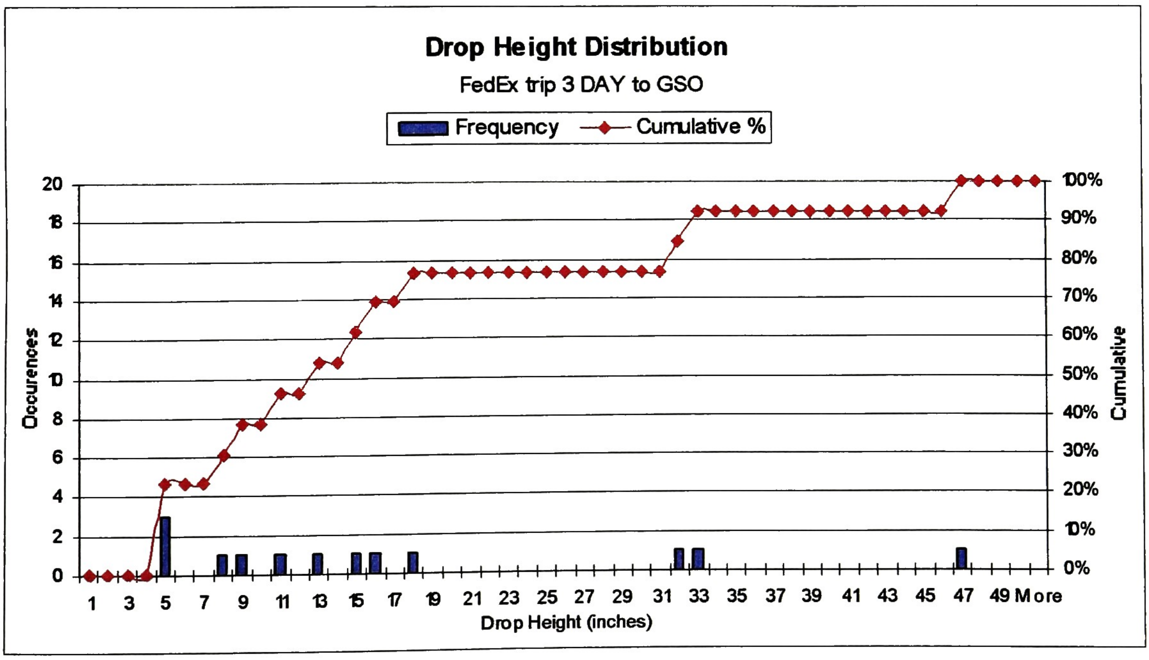


Figure 32. FedEx trip 3 - DAY to GSO

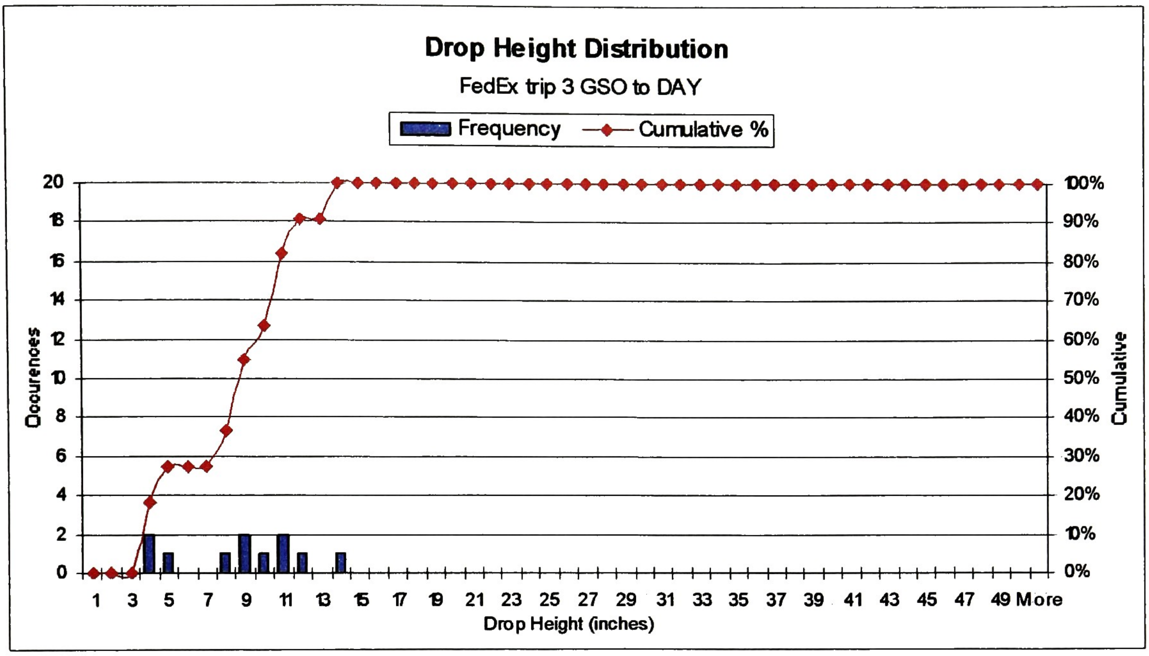


Figure 33. FedEx trip 3 - GSO to DAY

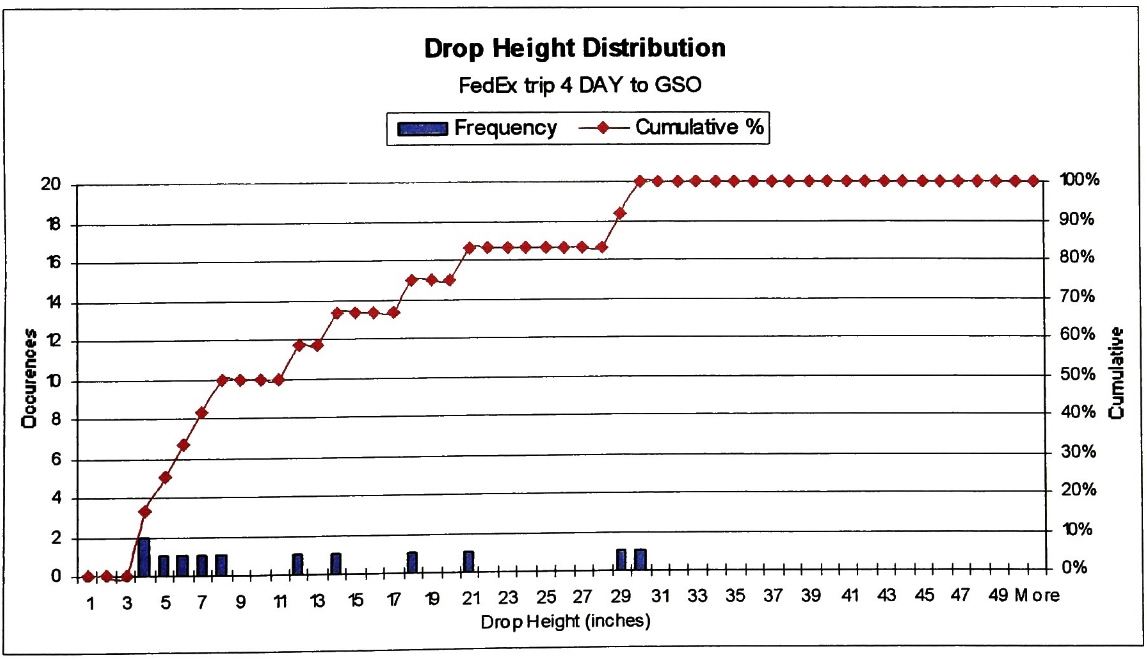


Figure 34. FedEx trip 4 - DAY to GSO

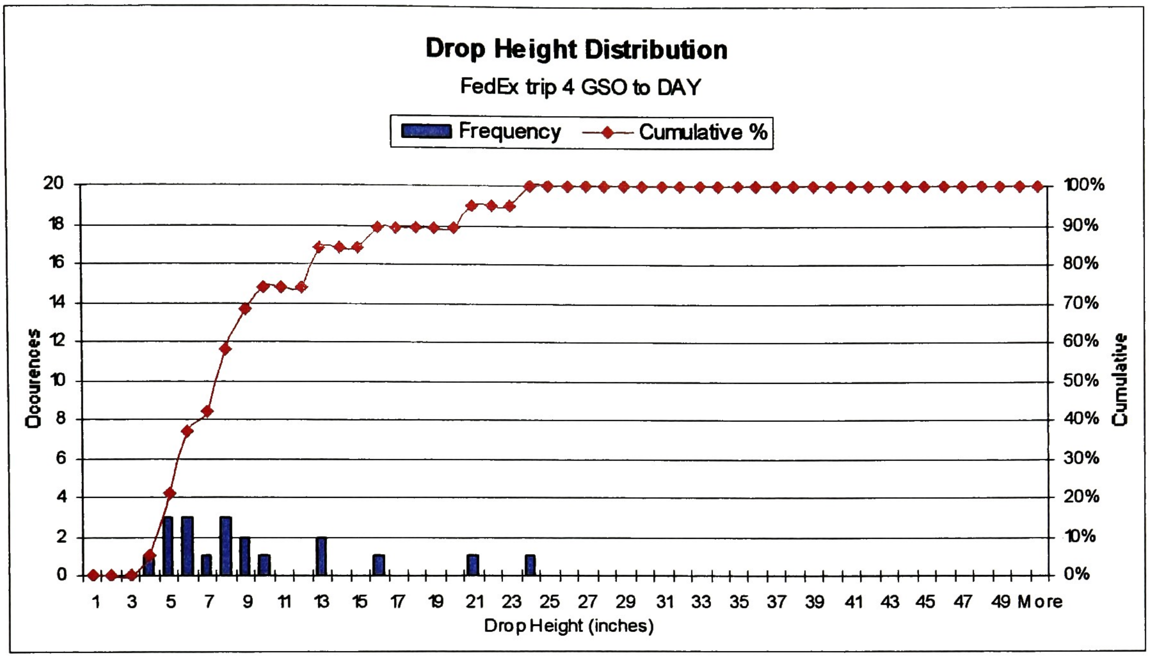


Figure 35. FedEx trip 4 - GSO to DAY

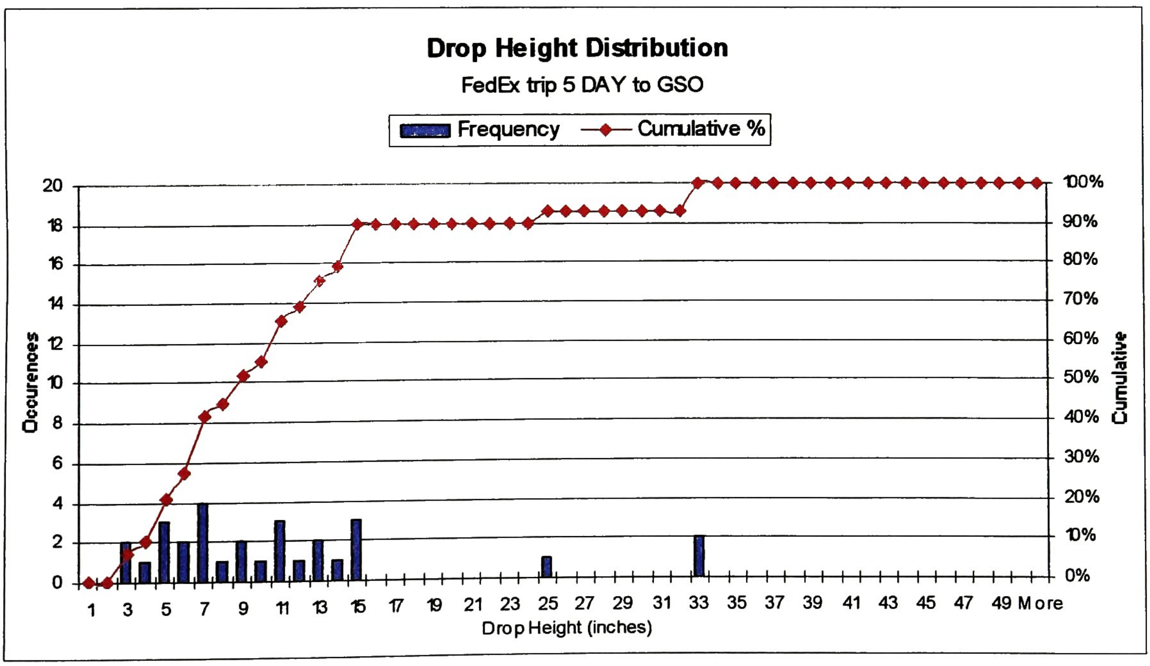


Figure 36. FedEx trip 5 - DAY to GSO

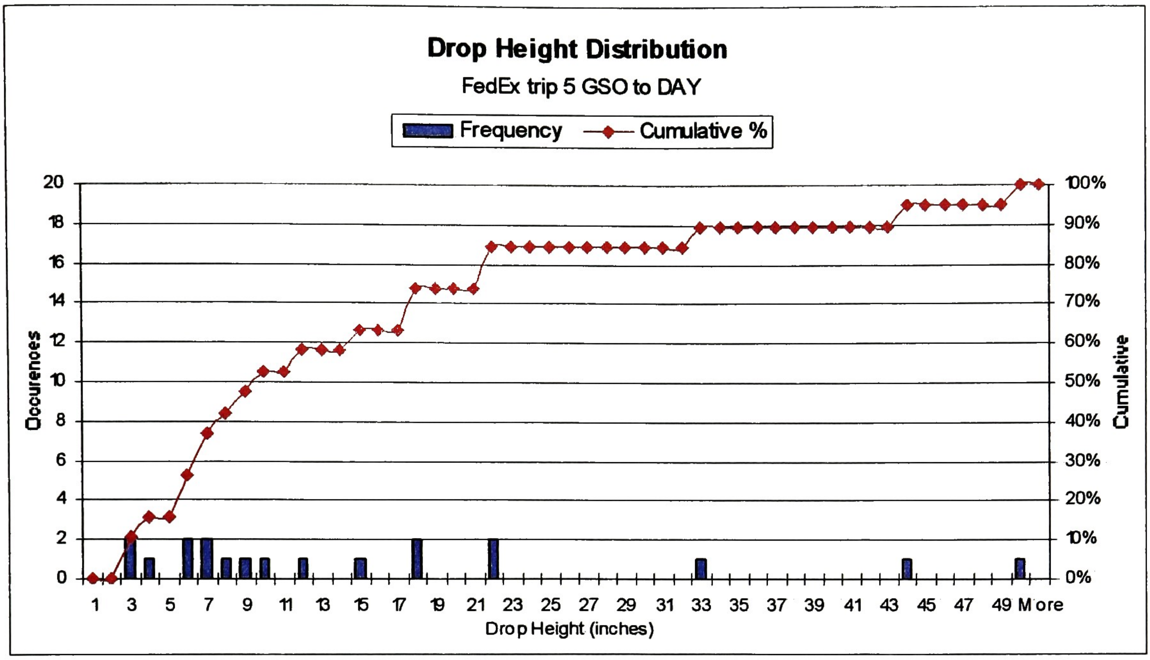


Figure 37. FedEx trip 5 - GSO to DAY

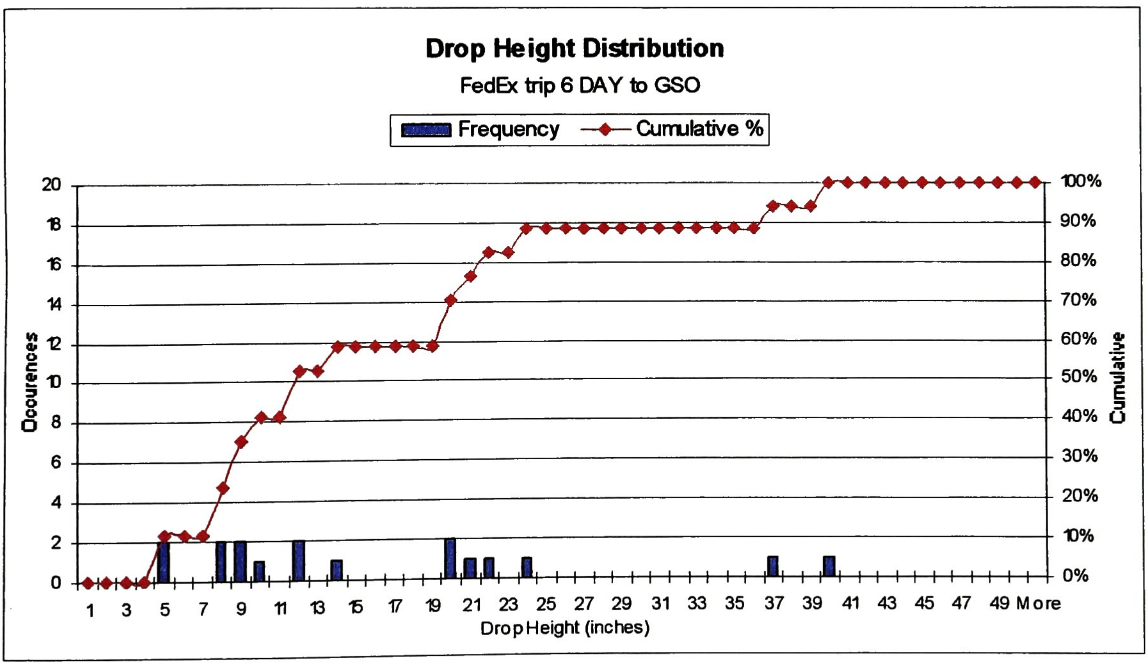


Figure 38. FedEx trip 6 - DAY to GSO

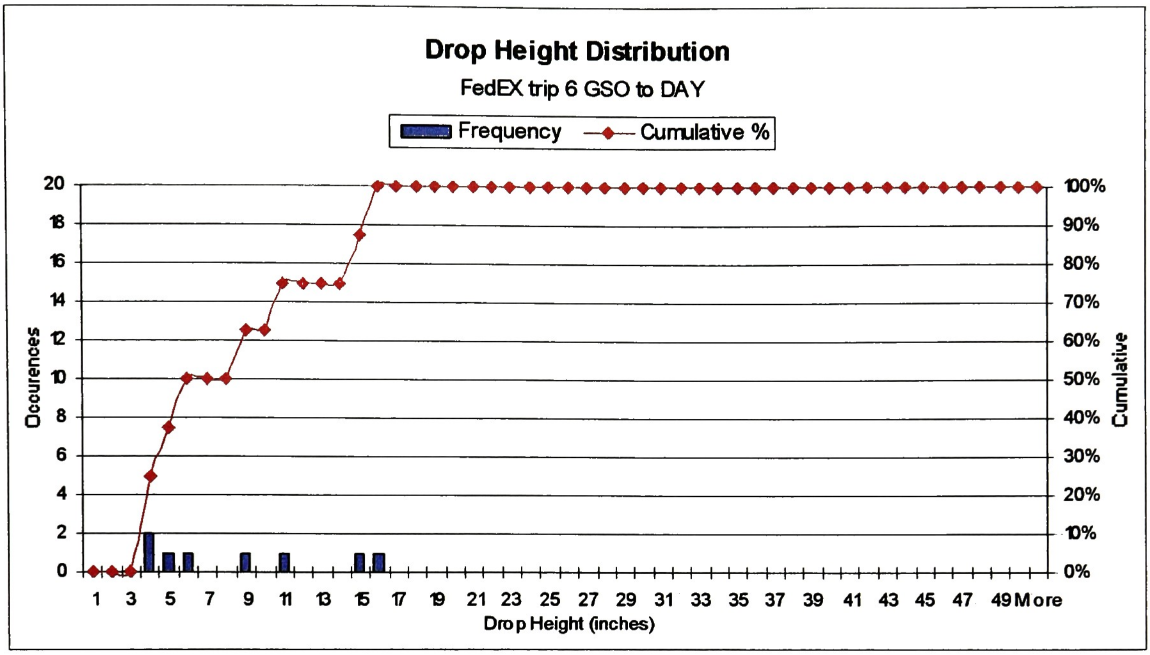


Figure 39. FedEx trip 6 - GSO to DAY

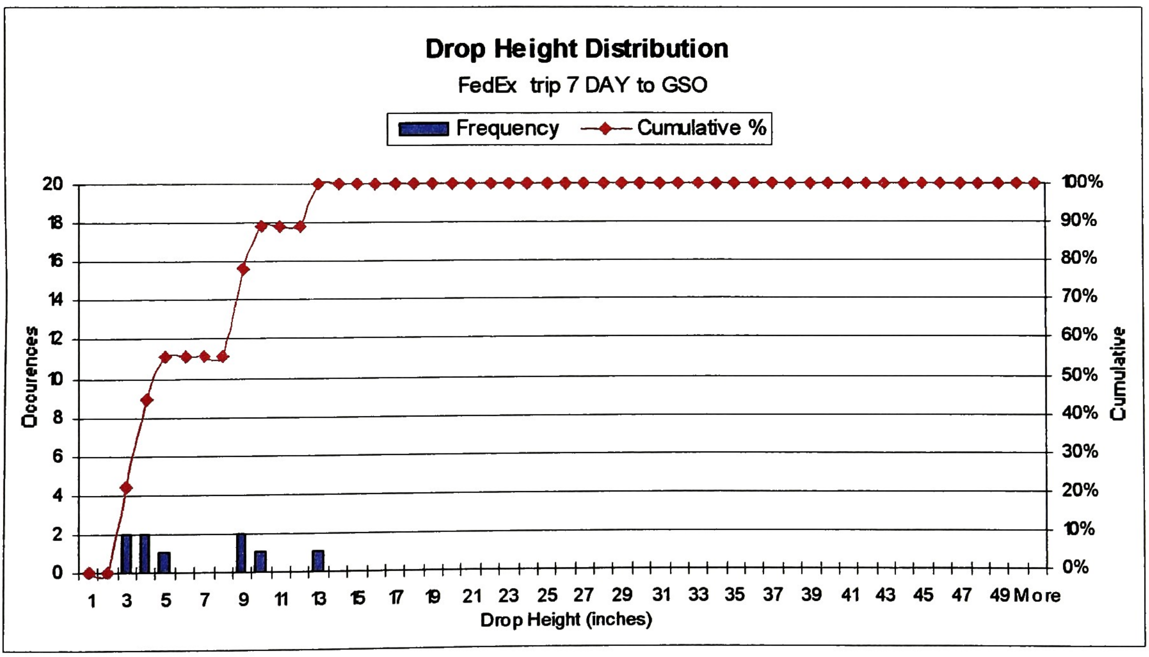


Figure 40. FedEx trip 7 - DAY to GSO

Appendix E

FedEx and UPS Combined Data Tables

All FedEx trips combined		
Drop Height (inches)	*Frequency*	*Cumulative %*
1	1	0.64%
2	0	0.64%
3	6	4.46%
4	13	12.74%
5	16	22.93%
6	9	28.66%
7	10	35.03%
8	12	42.68%
9	15	52.23%
10	6	56.05%
11	8	61.15%
12	6	64.97%
13	6	68.79%
14	5	71.97%
15	6	75.80%
16	4	78.34%
17	0	78.34%
18	5	81.53%
19	0	81.53%
20	2	82.80%
21	3	84.71%
22	4	87.26%
23	0	87.26%
24	4	89.81%
25	1	90.45%
26	1	91.08%
27	1	91.72%
28	0	91.72%
29	2	92.99%
30	1	93.63%
31	0	93.63%
32	1	94.27%
33	4	96.82%
34	0	96.82%
35	0	96.82%
36	0	96.82%
37	1	97.45%
38	0	97.45%
39	0	97.45%
40	1	98.09%
41	0	98.09%
42	0	98.09%
43	0	98.09%
44	1	98.73%
45	0	98.73%
46	0	98.73%
47	1	99.36%
48	0	99.36%
49	0	99.36%
50	1	100.00%
More	0	100.00%

Table 1. All FedEx trips combined

All UPS trips combined		
Drop Height (inches)	*Frequency*	*Cumulative %*
1	2	1.65%
2	0	1.65%
3	1	2.48%
4	5	6.61%
5	15	19.01%
6	18	33.88%
7	9	41.32%
8	5	45.45%
9	13	56.20%
10	11	65.29%
11	7	71.07%
12	8	77.69%
13	4	80.99%
14	0	80.99%
15	1	81.82%
16	2	83.47%
17	1	84.30%
18	4	87.60%
19	1	88.43%
20	2	90.08%
21	3	92.56%
22	2	94.21%
23	0	94.21%
24	0	94.21%
25	0	94.21%
26	0	94.21%
27	1	95.04%
28	3	97.52%
29	0	97.52%
30	0	97.52%
31	0	97.52%
32	2	99.17%
33	0	99.17%
34	0	99.17%
35	0	99.17%
36	0	99.17%
37	0	99.17%
38	0	99.17%
39	0	99.17%
40	0	99.17%
41	0	99.17%
42	0	99.17%
43	0	99.17%
44	0	99.17%
45	0	99.17%
46	0	99.17%
47	0	99.17%
48	0	99.17%
49	0	99.17%
50	1	100.00%
More	0	100.00%

Table 2. All UPS trips combined